GROUNDFISH

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OVERVIEW

The majority of West Coast groundfish populations have a stable abundance and population structure. However, 10% of groundfish stocks are declining in abundance and nearly 20% of stocks show declines in the percentage of mature individuals.

EXECUTIVE SUMMARY

Groundfish are an important component of the California Current. We identified population size and population condition as key attributes of groundfish stocks, and we identified and evaluated 46 indicators of these two attributes for use on the 90+ groundfish stocks of the California Current. We selected two indicators as indicators of population size: 1) biomass of groundfish relative to either the estimate of un-fished biomass (when a stock assessment is available) or trends in the survey time series, and 2) the number of assessed species below management thresholds. Additionally, two indicators of population condition were selected: 1) the proportion of the population mature (using ages or size in the absence of ages), and 2) the 95% cumulative age or length of the population. In general, data sources that relied on fishery-independent data performed better during the indicator selection process than fishery-dependent data sources (e.g., commercial landings numbers, total catch). In addition to these indicators, groundfish data were used in construction of several indicators in the **Ecological Integrity** chapter of this report.

We summarized the status of stocks (based on biomass trends) and population demographic condition (as measured by the percentage of mature individuals and of maximum age or size) for 30 groundfishes. The remaining species did not have sufficient data to determine their status at this time. We found that most assessed groundfishes are above the biomass limit reference point, and thus are not overfished (Figure GFi). The four assessed stocks currently in an overfished state are all rockfishes. All assessed groundfishes are below their target catch, thus overfishing is not occurring in these stocks. With respect to population condition measures, we discovered that age or length structure tended to show more changes (usually declines) over time than the proportion that are sexually mature. We also found that non-elasmobranch groundfishes tended to exhibit the most changes over time in both measures, with rockfishes being most sensitive to demographic changes. The development of additional data-limited methods may allow more species to be included in future iterations of the IEA.

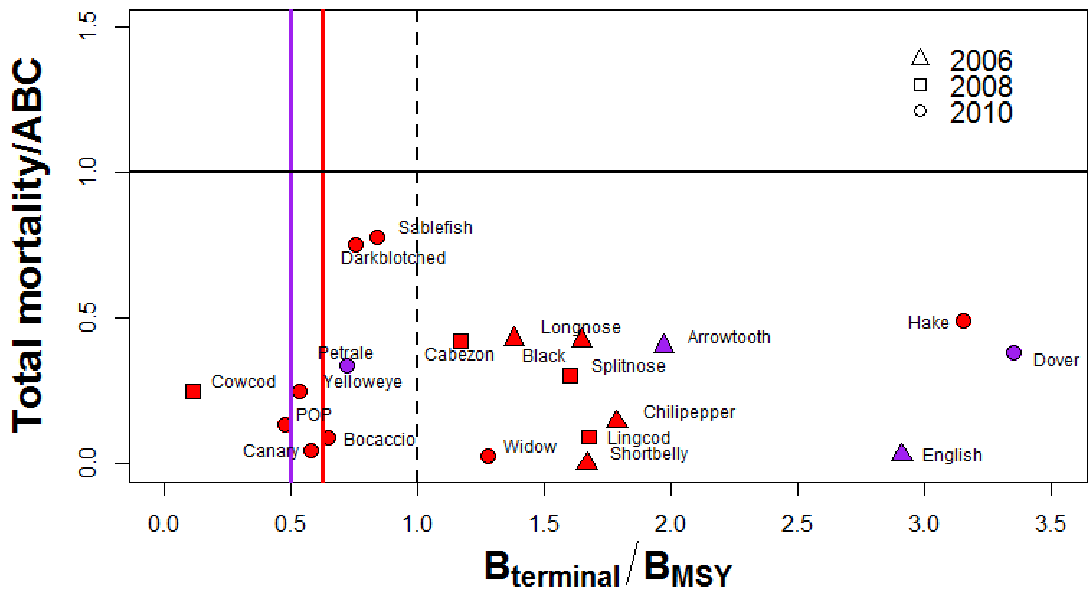

Figure GFi. Stock status plot relative to being overfished (x-axis) and overfishing (y-axis) for all species assessed since 2007. Vertical broken line indicates the target biomass reference point. Vertical solid line indicates the limit reference point indicating an overfished status (red for elasmobranchs, rockfishes, and roundfishes; purple for flatfishes). Horizontal line indicates overfishing wherein total mortality exceeds the allowable biological catch (ABC). For example, sablefish is below the target (black vertical broken line), but above the limit (red vertical solid line) biomass target, and below the overfishing limit (horizontal solid line). Symbols indicate the terminal year of the assessment in which the reference points are determined.

Table GFi. Results for each stock evaluated for each of two status indicators: 1) Biomass and 2) Population structure. Two sources of information were used: 1) Stock assessments and 2) Northwest Fisheries Science Center (NWFSC) shelf-slope trawl survey, when assessments were not available, or older than 2007. "Depletion" refers to the relative change in spawning biomass; "5-year trend" is the trend in the last 5 years of the time series (details found in the text). "B final year" is the biomass value in the final year compared to the 5-year average. "Prop. mature" is proportion of the population mature relative to the beginning of the time series; "95% cum." refers to the 95% cumulative age or length of the population relative to the beginning of the time series. +: above target limit or increasing; ●: between target and limit or stable; -: below limit or decreasing. Blank spaces indicate no information reported.

		Biomass				Population structure			
		Assessment		NWFSC Survey		Assessment		NWFSC Survey	
Taxa	Stock	Depletion	5-yr trend	B final year	5-yr trend	Prop. mature	95% cum. age	Prop. mature	95% cum. lt.
Elasmobranch	Longnose skate	+	●	●	●	●	-	●	●
	Spiny dogfish	+	●			●	-		
	Spotted ratfish			●	●			+	●
Flatfishes	Arrowtooth flounder	+	+	●	+	-	-	-	-
	English sole	+	+	●	●	+	-	-	●
	Pacific sanddab			●	+			●	●
	Petrale sole	●	●			-	-		
	Dover sole	+	●			●	●		
	Flathead sole			●	●			●	●
	Rex sole			●	-			●	●
Rockfishes	Black	+	+			-	-		
	Bocaccio	●	●			-	-		
	Canary	-	●			-	-		
	Chilipepper	+	●	●	●	●	-	-	+
	Cowcod	-	●			-	-		
	Darkblotched	●	+			-	-		
	Greenspotted	●	+			-	-		
	Greenstriped	+	+			●	-		
	Pacific Ocean perch	-	●			-	-		
	Redstriped			+	●			-	●
	Shortbelly			●	●			●	●
	Stripetail			●	●			●	●
	Widow	+	+			●	-		
	Yellowtail			●	●			●	●
	Aurora			-	-			-	●
	Blackgill	●	●			-	-		
	Splitnose	+	+			-	-		
	Yelloweye	-	●			-	-		
Roundfishes	Cabezon	+	+			-	-		
	Lingcod	+	+			-	-		
	Pacific Hake	+	+						
	Sablefish	●	-			●	●		

DETAILED REPORT

SUMMARY: INDICATORS

Forty six indicators of two attributes, population size and population condition, were evaluated. Two indicators were chosen for population size: 1) biomass of groundfish relative to either the estimate of unfished biomass (when a stock assessment is available) or trends in the survey time series, and 2) the number of assessed species below management thresholds. Two indicators were chosen for population condition, the proportion of the population mature (using ages or size in the absence of ages) and the 95% cumulative age or length of the population. Thirty groundfish species were identified for which these indicators would be calculated.

INDICATOR SELECTION

BACKGROUND - GROUNDFISH

Groundfish are generally defined as a community of fishes that are closely associated with the ocean bottom. In the CCLME, some of the better known species include the rockfishes (Scorpaenidae), flatfishes (Pleuronectidae and Bothidae), sculpins (Cottidae), Pacific hake, sablefish (*Anoplopoma fimbria*), greenlings and lingcod (Hexagrammidae), skates (Rajidae), and benthic sharks (PFMC 2008a). Similar to most fishes, many groundfish species have a planktonic larval and young-of-year life history stage in which young fish inhabit surface waters and feed on a diet of zooplankton. After a few months in the plankton, most species settle to the bottom, generally moving to deeper waters and they age/grow. Groundfish vary across a wide range of trophic levels and inhabit all types of habitats (e.g., rocky, sandy, muddy, kelp) from the intertidal zone to the abyss and have generally variable recruitment, often mature late, and are long lived.

This community of fishes constitutes a large biomass in the CCLME and provides the economic engine for coastal communities in Washington, Oregon, and California. The Pacific Fishery Management Council (PFMC) manages a subset of groundfish species that are typically captured during fishing operations along the U.S. West Coast. Those species caught in the Pacific groundfish trawl fishery were worth approximately $40 million in 2009 (NOAA Press Release 2010). Thus, understanding how groundfish populations fare over time is of great interest to ecosystem managers and the coastal communities that derive much of their wealth from this assemblage of fishes.

SELECTION PROCESS

Forty six potential indicators of groundfish population size and population condition were evaluated using the ecological literature as a basis for their rankings (see Levin and Schwing 2011 for detailed methods). Two indicators were chosen for population size: 1) biomass of groundfish relative to either the estimate of unfished biomass (when a stock assessment is available) or trends in the survey time series, and 2) the number of assessed species below management thresholds. Two indicators were chosen for population condition: 1) the proportion of the population mature (using ages or size in the absence of ages) and 2) the

95% cumulative age or length of the population. Thirty groundfish species were identified for which these indicators could be calculated.

POPULATION SIZE

Monitoring population size in terms of total number or total biomass is important for management and societal interests. For example, abundance estimates are used to track the status of threatened and endangered species and help determine whether a species is recovering or declining. Accurate population biomass estimates of targeted fisheries species are used to assess stock viability and determine the number of fish that can be sustainably harvested from a region. While population size can be used to assess population viability, more accurate predictions of viability can be obtained by including the mechanisms responsible for the dynamics of the population. Population dynamics thus provide a predictive framework to evaluate the combined effect of multiple mechanisms of population regulation (e.g., recruitment, mortality, immigration, and emigration) to evaluate changes in abundance through time.

POPULATION CONDITION

Whereas the preceding attribute is concerned with measures of population size, there are instances when the health of the population may be of interest. For example, monitoring changes in population condition may presage an effect on population size or provide insight into long-term population viability. The dynamics of many populations are better understood through knowledge of population conditions such as organism condition, age structure, genetic diversity, phenotypic diversity, and population structure. Impaired condition of any or all of these subcategories indicates biological resources at risk. In addition, monitoring changes in population condition could be used to infer changes in environmental conditions.

Table GF1. Selected key attributes for each goal. Relevant measures describe what each attribute means (e.g., population size is represented by the number of individuals in a population or the total biomass).

Goal	Key attribute	Relevant measures
Groundfish,	Population size	Number of individuals or total biomass, population dynamics, population size relative to unfished conditions (depletion)
	Population condition	Measures of population or organism condition including: age structure, population structure, phenotypic diversity, genetic diversity, organism condition

TOP RANKED INDICATORS

A total of 46 indicators were evaluated for the two key attributes: population size and population condition. In general, the indicators that were evaluated scored well against the primary considerations criteria; however, when indicators performed poorly, it was generally because data were not available at large spatial scales or across long time series.

ATTRIBUTE 1 - POPULATION SIZE

First three primary indicators that are obvious and well established were evaluated: numbers of individuals, total biomass of the population (when model estimates were available), relative biomass (when survey indices were available), and population growth rate. These indicators performed well across all three evaluation criteria categories and are supported as indicators of population size by primary literature sources (e.g., Fulton et al. 2005, Link 2005). However, the ability of scientists and managers to estimate the abundance or growth rate of any population of groundfish over time relies on survey indices of relative abundance. Thus, data sets that measure the relative abundance or biomass of groundfish populations over time (fishery dependent and fishery independent) are evaluated, providing an evaluation of the strengths and weaknesses of various data sources that estimate groundfish population size. A total of 29 potential indicators of population size in the CCLME are identified and evaluated (Table GF2).

In general, data sources that relied on fishery-dependent data (e.g., commercial landings numbers, total harvest biomass) did not perform well against the primary considerations evaluation criteria. For example, recreational landings data are generally collected at docks and only include individuals and species that are kept by fishers. Thus these data are highly biased by fisher behavior in what species are targeted and what species or individuals they retain. When fishery-independent indicators did not perform well, it was generally because these data sources the surveys did not occur at large spatial scales or over long time scales (e.g., NWFSC's hook-and-line surveys, scuba surveys). Interestingly, "local ecological knowledge" scored well in the primary considerations categories, but these interviews of people's memories simply do not exist for most of the CCLME. One attempt in Puget Sound by Beaudreau et al. (2011) has shown a correlation between relative abundance trends of marine species derived from interviews with fishers and divers and scientifically collected relative abundance survey data.

ATTRIBUTE 2 - POPULATION CONDITION

Seventeen potential groundfish indicators (Table GF3) were identified and evaluated. Indicators related to age structure, fecundity, or spatial structure of populations generally scored well in the primary considerations categories. Many condition indicators did not score well in the data considerations categories because there is simply little data available across the entire CCLME or data do not exist at multiple periods through time. For example, age at maturity and genetic diversity score high in primary considerations, but there are few examples from a limited number of species in which these data have been collected or processed. Collecting the data (e.g., gonads or fin clips) is relatively easy to do during bottom trawl surveys, but processing the samples can be expensive and taxing for current staff levels.

Table GF2. Summary of groundfish population size indicator evaluations. The numerical value that appears under each of the considerations represents the number of evaluation criteria supported by peer-reviewed literature. For example, CalCOFI egg/larvae abundance has peer-reviewed literature supporting two out of five primary considerations criteria.

Attribute	Indicator	Primary consider-ations (5)	Data consider-ations (7)	Other consider-ations (6)	Summary comments
Population Size	Biomass	5	7	4	While biomass for each species is an obvious indicator for individual species, aggregate groundfish biomass is not necessarily indicative of the state of the entire groundfish community due to changes in a few large components of the community.
Population Size	Numbers	5	7	4	Similar comment as for biomass above.
Population Size	Population growth rate	4	5	5	Theoretically sound and can be calculated at numerous spatial and temporal scales as datasets can be integrated.
Population Size	Number of groups below management thresholds	3	5	5	Good snapshot of species trends over time, but only 30 of 90 managed groundfish species are assessed.
Population Size	Stock assessment estimated biomass	5	7	5	Stock assessments perform well for data-rich species. Similar to above, only 30 of 90 groundfish species are assessed.
Population Size	Bottom trawl survey relative biomass	5	7	3	Multiple surveys have occurred; surveys generally provide two large scale independent time series, one from 1980to2004 and the second from 2003 to 2010.
Population Size	Bottom trawl survey relative numbers	5	7	3	Multiple surveys have occurred; surveys generally provide two large scale independent time series, one from 1980to2004 and the second from 2003 to 2010.

Population Size	Hake acoustic survey relative biomass	4	5	3	Effective indicator for the most abundant groundfish species in the CCLME, but may not reflect trends of other species. Survey has greater uncertainty when Humboldt squid are present.
Population Size	Hake acoustic survey relative numbers	4	0	0	Acoustic surveys generally calculate biomass, not numbers.
Population Size	Prerecruit survey relative biomass	3	3	3	The survey provides data on a limited number of species, is temporally limited, and has been historically centered on San Francisco (30 year time series). Since 2001 the survey has covered most of the U.S. West Coast between Cape Flattery and the U.S./Mexico border.
Population Size	Prerecruit survey relative numbers	3	3	3	Similar comment as above.
Population Size	Hook-and-line survey relative biomass	5	3	3	Survey is limited in spatial scale, but provides relative biomass trends in untrawlable habitats in the Channel Islands, California.
Population Size	Hook-and-line survey relative numbers	5	3	3	Similar comment as above.
Population Size	PISCO scuba surveys relative biomass	5	0	0	Scuba surveys are limited in spatial scale and highly variable for cryptic species.
Population Size	PISCO scuba surveys relative numbers	5	4	3	Similar comment as for PISCO scuba surveys biomass above.
Population Size	National Park Service kelp monitoring relative survey biomass	5	0	0	Similar comment as for PISCO scuba surveys biomass above.

Population Size	National Park Service kelp monitoring relative survey numbers	5	4	3	Similar comment as for PISCO scuba surveys numbers above.
Population Size	IPHC longline survey relative biomass	4	2	3	Longline surveys are useful for a small number of species.
Population Size	IPHC longline survey relative numbers	4	2	3	Similar comment as above.
Population Size	CalCOFI egg/larvae relative abundance	2	3	3	Survey most effective for limited pelagic species, limited information for groundfish. DNA methods needed to ID most larval rockfish.
Population Size	Pot surveys relative biomass	1	1	3	Variation in behavior of fish biases these passive survey methods. Survey no longer occurs.
Population Size	Pot surveys relative numbers	1	1	3	Similar comment as above.
Population Size	Commercial landings biomass	1	3	1	Fishery-dependent data biased toward fisher behavior, fleet dynamics and management restrictions. Only economically valuable species.
Population Size	Commercial landings numbers	1	2	1	Similar comment as above.
Population Size	Recreational landings biomass	1	3	1	Similar comment as above.
Population Size	Recreational landings numbers	1	3	1	Similar comment as above.

Population Size	Total harvest biomass, catch per unit effort	1	4	1	Similar comment as above.
Population Size	Bycatch abundance	0	5	4	Levels of bycatch are heavily influenced by fisher behavior and management restrictions.
Population Size	Local ecological knowledge	4	1	4	Theoretically sound, but limited data throughout the CCLME.

Table GF3. Summary of groundfish population condition indicator evaluations. The numerical value that appears under each of the considerations represents the number of evaluation criteria supported by peer-reviewed literature. For example, Cortisol/vitellogenin has peer-reviewed literature supporting two out of five primary considerations criteria.

Attribute	Indicator	Primary consider-ations (5)	Data consider-ations (7)	Other consider-ations (6)	Summary comments
Population Condition	Age structure of populations	5	7	4	Strongly supported by the literature. Data are often limited to assessed species or those likely to be assessed in the near future due to the difficulty and expense of aging otoliths.
Population Condition	Size structure of populations	0	5	4	Size structure from catch data generally biased by gear selectivity and catchability.
Population Condition	Center of distribution (latitudinal or depth)	2	5	5	Distributional shifts tend to suggest a pressure is acting on the population (i.e., fishing or climate).

Population Condition	Genetic diversity of populations	5	2	2	Scores well in primary considerations, but there is an overall lack of data for most groundfish species at multiple points in time.
Population Condition	Age at maturity	5	1	3	Similar comment as above.
Population Condition	Size at maturity	3	2	2	Similar comment as above.
Population Condition	Diet of groundfish	0	1	1	Prey is highly variable and there are few species with enough data over time and space to understand differences.
Population Condition	Larval abundance	2	3	2	Abundance of larvae most likely driven by oceanographic conditions and not be reflective of the condition of specific populations.
Population Condition	Parasitic load	3	1	0	Theoretically sound but little data for most species.
Population Condition	Condition factor (K)	3	5	2	Theoretically sound. condition of fish is related to growth and fecundity, but generally not described. Data limited to species with both individual length and weight measurements during surveys.
Population Condition	Cortisol/vitellogenin	2	1	1	May be related to condition, but changes in the attribute are not likely to vary with this indicator at any scale but the very smallest.
Population Condition	Disease (liver and gall bladder)	2	1	1	Similar comment as above.

Population Condition	Fecundity	5	1	2	Scores well in primary considerations, but there is an overall lack of data available for most species across time and space.
Population Condition	Body growth	2	5	5	Typically, age is calculated from otoliths collected during bottom trawl surveys, but growth could also be measured with these samples.
Population Condition	Spatial structure of population	5	5	4	Theoretically sound and data are available for many species, but stocks are generally assessed at the scale of the entire coast.
Population Condition	Mean length of species	5	1	5	Lengths measured for many species, but there may be limited data on unassessed species.
Population Condition	Rebuilding timeline	3	7	5	Available for overfished species. Most species stop declining, but some have not increased.

POPULATION SIZE

STOCK ASSESSMENT ESTIMATES OF BIOMASS AND DEPLETION

Stock assessment trends in estimate spawning stock biomass are well established measures of the size of the many commercially important species and are subject to intense peer review. Assessments are tied directly to management efforts and provide quota levels for various fisheries. Changes in assessed populations often reflect changes in the relative abundance of individuals collected in bottom trawl surveys. When management restrictions are established, assessed populations generally stop declining. Many species begin to recover and experience population growth according to the assessments, but there are other species that appear to respond slowly to management actions (see Miller et al. 2009). Assessments provide estimates of stock status relative target and limit reference points established by the Pacific Fishery Management Council for assessed species. The target reference point is B40, 40% of the unfished spawning biomass, the level of spawning stock biomass at which stocks are considered at their optimal yield (B25% for flatfish). The limit reference point is B25, 25% of unfished spawning biomass, the level of spawning stock biomass at which stocks are overfished (5% for flatfish). However, only 30 of 90-plus species within the Pacific Coast Groundfish Fishery Management Plan (PCGFMP) have been assessed and there are generally hundreds of species of fish detected each year in the groundfish trawl surveys that have been conducted off of the U.S. west coast (e.g., Keller et al. 2008).

Stock assessments use data from multiple sources, but the primary sources of data are from two fishery independent surveys. The first survey was conducted by the Alaska Fisheries Science Center's (AFSC), the triennial bottom trawl survey, and covers every third year from 1977 to 2001. During 2004 the Northwest Fisheries Science Center (NWFSC) conducted the final year of the triennial bottom trawl survey. The NWFSC has conducted a separate fishery independent bottom trawl survey annually from 2003 to 2011. The spatial extent and timing of the AFSC triennial survey varied over time. The NWFSC annual survey has a consistent random-stratified design by depth that samples the entire U.S. West Coast from depths of 50 to 1,280 m (Figure GF1). Assessments use multiple data sources incorporating length frequencies, diet, age structure, and fecundity measures when available. Analyses used to generate time series data generally use the same stock assessment framework (Stock Synthesis, e.g., Stewart 2009). Assessments generally use multiple data sources across the range of each stock (e.g., Gertseva et al. 2009, Stewart et al. 2009); however, some species (i.e., cabezon [*Scorpaenichthys marmoratus*] and bocaccio [*Sebastes paucispinis*]) are only assessed in specific regions along the West Coast (Cope and Key 2009, Field et al. 2009).

The major findings of a stock assessment are routinely used by the public and policy makers (i.e., a population is declining, increasing, or overfished). Assessments are typically done for species that are commercially important fishery targets, for species that may be subject to bycatch in targeted fisheries, or for species for which good fishery independent survey data exists. Since assessments estimate spawning biomass, it is generally an assessment of processes that have already taken place (i.e., the impact of fishing and variable recruitment strengths), so this is generally a lagging indicator.

BOTTOM TRAWL RELATIVE SURVEY BIOMASS

The AFSC triennial trawl and the NWFSC annual trawl surveys are well established and analysis methods for these surveys have been developed with input by stock assessment scientists and through outside peer review during the PFMC stock assessment review (STAR) and science and statistical committee review (SSC) processes. The major objective of these surveys is to provide the fishery-independent data necessary to conduct formal stock assessments of fish species managed within the PFMC GFMP (Keller et al. 2008). The NWFSC annual survey collects data in trawlable habitats from the U.S.-Canada border to the U.S.-Mexico border between the months of May to October. Each trawl is 15 minutes in duration and total counts and aggregate weights by species are recorded for all species. Subsamples of targeted species (generally consisting of the 90 managed species) are randomly selected for individual measurements of length and weight, removal of age structures, and sex determination. In a typical year, approximately 600 trawls are successfully conducted; approximately 150,000 fish are individually measured for weight and length, and more than 20,000 otoliths are removed for aging (Keller et al. 2008). Some species are sampled for genetics, stomach contents, maturity level, and toxicology as special projects. These data are in a Fishery Resource Analysis and Monitoring Division (FRAM) database at NWFSC.

The trawl survey data allow for estimates of density and biomass and evaluation of the relative change in population size over time for many more species than are assessed through formal stock assessments (e.g., Levin et al. 2006). As noted, only 30 of the 90-plus managed species on the U.S. West Coast are formally assessed, while there are hundreds of species or groups of fish detected each year during the NWFSC annual trawl survey. One caveat to the bottom trawl survey is that the data are biased towards species that occupy trawlable habitats in depths from 50 to 1,280 m (there is no near shore groundfish survey) and those life history stages that are selected to the survey trawl gear. Most small individuals, either young individuals or smaller species, are not captured by the bottom trawl survey because they are in shallower water as juveniles or they escape through the net mesh. Moreover, species that move into rockier and untrawlable habitats with increasing age or size are not sampled by the bottom trawl survey. The bottom trawl survey is also not a good indicator of Pacific hake biomass, which is a more pelagic species and comprises the largest component of the groundfish population in the CCLME from a fisheries standpoint (Miller et al. 2009). This holds true for other pelagic species as well.

Estimates of relative abundance calculated from trawl surveys are easily understood by the public and have been used historically by policy makers for regulatory and legislative purposes. The estimates of relative abundance from the trawl survey are generally a lagging indicator of past stock population dynamics (i.e., what were the conditions of the ecosystem that allowed recruitment to be good or bad). Many species are captured in the survey prior to being selected by the commercial fishery, providing early information about the strength of incoming recruitments for the fishery.

Biomass. Biomass is a standard measurement of population size and is cited voluminously in the indicator literature (e.g., Fulton et al. 2005, Link 2005). Biomass is the metric estimated in formal stock assessments and the metric used for harvest rates of individual species in West Coast fisheries. However, an aggregate estimate groundfish biomass is not necessarily indicative of the state of the groundfish community, because this information will be biased towards a few large components of the community. For example, Pacific hake is the most abundant groundfish species detected in the NWFSC annual trawl survey and variation in hake abundance can swamp detectable variation in the rest of the groundfish community. Thus any groundfish community indicator will need to identify species of interest or representatives of different functional groups to monitor changes over time. Alternatively, multivariate measurements of the groundfish community will need to be developed to detect meaningful changes in the population size of groundfish.

HAKE ACOUSTIC SURVEY BIOMASS

The Pacific hake integrated acoustic and trawl survey has been conducted since 1977 to assess the size and distribution of the population in the CCLME (Helser and Martell 2007, Helser et al. 2008). The joint survey between the United States and Canada has taken place in 1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998, 2001, 2003, 2005, 2007, 2009, and 2011. The survey is generally conducted between June and August along the continental slope and shelf from Monterey, California (lat 35.7°N), to the Dixon Entrance in northern British Columbia (lat 54.8°N). However, survey methods have varied over time, particularly prior to 1995. During the survey, hydroacoustics are used to measure acoustic backscatter that is that attributed to hake. The size and age structure of the acoustic backscatter is quantified by trawl tows over a subset of the areas that have been identified as hake, and then numbers (or biomass) are calculated. This survey is a single species survey that does not provide adequate information for other groundfish species. In addition, massive northward movements of Humboldt squid (*Dosidicus gigas*) can complicated the survey (e.g. the 2009 survey year). Since it is very difficult to distinguish between Pacific hake and Humboldt squid with the current acoustic survey methodologies, changes in the spatial distribution and frequency of occurrence of Humboldt squid in the survey area may pose problems in the future.

Similar to the bottom trawl surveys, the acoustic survey produces data that are commonly used by the public and policy makers, have been used historically, and are compatible with measurements used by other regions and nations.

NUMBER OF GROUPS BELOW MANAGEMENT THRESHOLDS

A simple indicator of the status of assessed groundfish species is the number of species that are currently below various management thresholds. The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) requires fishery conservation and management measures that prevent overfishing, while achieving optimum yield on a continuing basis (16 U.S.C. §1851a1). Overfishing occurs when the actual catch of a species exceeds the allowable catch for that species. The MSFCMA also requires that fishery management plans specify objective and measureable criteria for identifying when a fishery is overfished and contain conservation and management measures to prevent or end overfishing and rebuild the fishery (16 U.S.C. §1853a10). Under the PFMC GFMP, a species (or stock) is considered overfished when its current spawning stock biomass is assessed to be below that limit reference point. NMFS's national standard guidelines clarify that "overfished" relates to biomass of a stock or stock complex, while "overfishing" pertains to a rate or level of removal from a stock or stock complex (50 CFR 600.310(e)(2)). Estimates of spawning stock biomass and unfished biomass are calculated during the formal stock assessment analysis.

Data to measure the overfishing threshold is available for all stocks that have an identified allowable catch. Approximately 30 of the 90-plus managed groundfish species can be evaluated for the overfished threshold. Data from the NWFSC annual trawl survey alone are not sufficient for evaluating whether or not a stock is below the overfished threshold because the survey covers a small fraction of the exploitation history for most groundfish stocks, making the determination of overfished status from survey data alone subject to the problem of shifting baselines (i.e. it is impossible to estimate the size of the stock at the beginning of the its exploitation with survey data that begins at a much later date.

Policy makers have used whether a species is above or below specific management thresholds for regulatory and legislative purposes. Other nations have similar thresholds in their management frameworks (Gray et al. 2010).

POPULATION CONDITION

AGE STRUCTURE OF POPULATIONS

The longevity of many groundfish species allows them to allocate their reproductive output across many years. This strategy is particularly important when environmental conditions are unfavorable for survival of larvae or new recruits (Leaman and Beamish 1984, Berkeley 2004a). In addition, there is growing support in the literature that older fish produce more fit eggs and larvae (Hislop 1988, Berkeley 2004a, Wright and Gibb 2005, Sogard 2008), suggesting that older individuals may produce offspring that will survive and recruit to the population in higher proportions than offspring from younger individuals. Higher survival rates for offspring from older individuals could be particularly true during years when environmental conditions are less than optimal. Thus populations with a truncated age structure (fewer older individuals) may have more difficulty sustaining current population levels. For many groundfish species, the largest and oldest individuals have been historically targeted and removed by fishing practices; many groundfish species subjected to fishing pressure have a truncated size (and age) structure compared to historical, unfished size (age) structure (Jennings and Blanchard 2004, Blanchard et al. 2005). Reference points have not been established for size (age) structure indicators, but similar reference points have been suggested for the indicator mean size that would set reference points at the median size (age) of maturity.

The NWFSC annual groundfish survey collects otoliths for most managed species and age structures should be available for beginning in 2003. Data for other species varies, but are typically limited to small spatial scales and to single data collections in time. The temporal variability in age structure is a function of fishing as well as other less clearly understood factors, spatial variability is not well understood in the CCLME for most species.

The importance of age structure to the success of fish populations, older individuals are generally larger and generally produce more and stronger offspring, is recognized by policy makers. Age structure is inherently used by policy makers because stock assessments use spawning stock biomass as the fundamental metric, which is related to the age of individuals when they mature.

REBUILDING TIMELINE

For groundfish species in the PFMC GFMP, if a species population size is assessed to be below the limit reference point it is declared overfished and a rebuilding plan must be developed. A rebuilding plan establishes an allowable harvest rate that will enable the species to rebuild to its target reference point within an adequate period of time based on the minimum time of recovery, assuming no fishing (PFMC (Pacific Fishery Management Council) 2010). The rebuilding timeline varies dramatically among species. For example, under current management harvest rates, cowcod (*Sebastes levis*) are predicted to rebuild by 2071, while widow rockfish (*Sebastes entomelas*) were declared rebuilt during 2011. When management action is taken, such as reductions in harvest rate, most species stop declining, but the rate at which they rebuild varies (Miller et al. 2009). Rebuilding timelines are only developed for those species declared overfished, so there are a limited number of species with rebuilding rate calculations.

This indicator is commonly used by the public and policy makers. It is also easy to understand which species are having a difficult time rebounding from historical pressures.

SPATIAL STRUCTURE OF POPULATIONS

The spatial structure is a measure of the geographic range and distribution of a species or stock. Most groundfish species in the PFMC GFMP are managed as a single stock, but there is some evidence that the genetic composition of recruits may be quite complicated spatially (Larson and Julian 1999, Berkeley 2004b). The youngest recruits are found to have different genetic diversity and haplotypes from older year-classes or adults. This suggests that the geographic source of successful recruits may differ from year to year and that some populations may be reproductively isolated depending on oceanic conditions(Miller et al. 2005). Thus understanding how spatial structure may have changed over time may help our understanding of the connectivity of species across large spatial scales such as the CCLME. Distributional shifts are hypothesized to occur for either of two reasons climatic or exploitation, but the difference is difficult to distinguish. Perry et al. (2005) showed large latitudinal shifts correlated with changes in temperature due to climate change. Changes in latitudinal and depth distribution of groundfish assemblages can be due to ontogenetic movement, fishing pressure, and changes in climate (Fairweather et al. 2006, Coetzee et al. 2008, Dulvy et al. 2008).

As predicted, the geographic ranges of many overexploited species typically shrink, and stocks are concentrated into smaller regions following population declines (Atkinson et al. 1997, Garrison and Link 2000). Moreover, shrinking spatial distribution may limit the ability of a population to find suitable environmental conditions for offspring (Berkeley 2004b). Some changes in species spatial distributions may even result in population extinctions (Thomas et al. 2004, Drinkwater 2005). Reference points for distributional shifts are not currently defined or used and would be difficult to measure unless species were divided into and managed as distinct population segments.

The AFSC triennial survey and the NWFSC annual survey have collected data on the density and distribution of the CCLME groundfish assemblages for nearly 30 years. However, due to different survey methods these two surveys cannot be treated as a single time series. At this time, Pacific hake is the only species known to shift distribution with changes in environmental conditions, exploitation, or changes in population condition (Ressler et al. 2007).

In general, shifting or changing patterns of spatial distribution are easily understood by the public and policy makers. Spatial distribution data have been transmitted to the public in the past in the context of invasive species for terrestrial, freshwater, and marine systems. For example, the annual variability in the northern extent of the geographic range of Humbolt squid may have strong trophic impacts in the CCE. The ability to detect spatial shifts in distribution or range is likely to occur at long time scales for noninvasive species, so spatial structure should be a lagging indicator of changes in the population condition.

MEAN SIZE OF ALL SPECIES

The mean size (measured by length or weight) of all species caught in fishery-independent surveys, fishery-dependent surveys, or landings has been used to evaluate changes in an ecosystem (Link and Brodziak 2002, Link et al. 2002, Rochet and Trenkel 2003, Nicholson and Jennings 2004, Sala et al. 2004). A decrease in mean size is expected and has been observed in heavily fished systems (Haedrich and Barnes 1997, Levin et al. 2006, Methratta and Link 2006). However, the sensitivity of changes in mean size to environmental conditions is not well understood (Rochet and Trenkel 2003). One study suggests changes greater than 30% in mean length from one year to the next be set as a reference point (Link 2005), while another study suggests the reference point be set at the median length at maturity (Caddy and Mahon 1995).

In the groundfish trawl surveys, subsamples of targeted species (up to 100 per trawl) are individually measured for length and weight. In order to monitor this indicator with fishery-independent data, all species would need to be sampled and measured in some fashion. However, this metric can be calculated using fisheries landings data (Link 2005),so historical data are available via Pacific Fisheries Information Network (PacFIN, http://pacfin.psmfc.org/).

This indicator is easily understood and is being used in other regional ecosystems (Link 2005). Similar to other indicators, mean size of all species is most likely to be a lagging indicator of the population condition because the size structure may be the result of environmental conditions acting on each individual since it was born.

AGE AT MATURITY

Population parameters such as age and size at maturity are adaptive traits and there is increasing support in the literature for rapid evolution of these life history characteristics (Haugen and Vollestad 2001, Stockwell et al. 2003). As with the discussion of age structure as an indicator, significant changes in a population's age at maturity can signal extreme pressures that may have significant impact on a population's ability to sustain itself and ought to be cause for concern (Olsen et al. 2004). Declines in age-at-first-maturity have been commonly associated with compensatory responses to a reduction in population size (Trippel 1995, Berkeley 2004b). There are multiple examples in which age at maturity has declined in heavily exploited groundfish populations such as Atlantic cod (*Gadus morhua*) (Beacham 1983a), haddock (*Melanogrammus aeglefinus*) (Beacham 1983b), American plaice (*Hippoglossoides platessoides*) (Trippel 1995), and community-wide measurements (Greenstreet and Rogers 2006). In most studies, age at maturity declined during periods of exploitation, as evolutionary theory would predict, but striped bass (*Morone saxatilis*) in coastal Rhode Island showed a 15% increase in age at maturity over a 46-year period (Berlinsky et al. 1995). Olsen et al. (2004) provide a framework for Atlantic cod reference points that would provide managers with early warning signals about changes in this indicator.

Estimates of age at maturity exist for most managed groundfish species, but sampling generally occurred across short temporal scales (Gunderson et al. 1980, Echeverria 1987, Love et al. 2002, Thompson and Hannah 2010). There are a few examples of multiple studies that measured age at maturity at various points in time at different locations within the CCLME, for example, canary rockfish (*Sebastes pinniger*) from California, Oregon, Washington, and British Columbia at various times between 1960 and 1982 (Phillips 1964, Westrheim 1975, Gunderson et al. 1980, Echeverria 1987). Age structures (otoliths, dorsal spines, and fin rays) are collected from targeted species during the NWFSC annual trawl survey and gonads are collected as special projects from time to time. However, most groundfish are in need of new data on maturity and fecundity relationships, because methods have been inconsistent across studies and there are few examples of estimates over time (Stewart 2008). Age at maturity is an easy indicator to understand for the public and policy makers, but this indicator has not been used because of the general lack of data over time for most species.

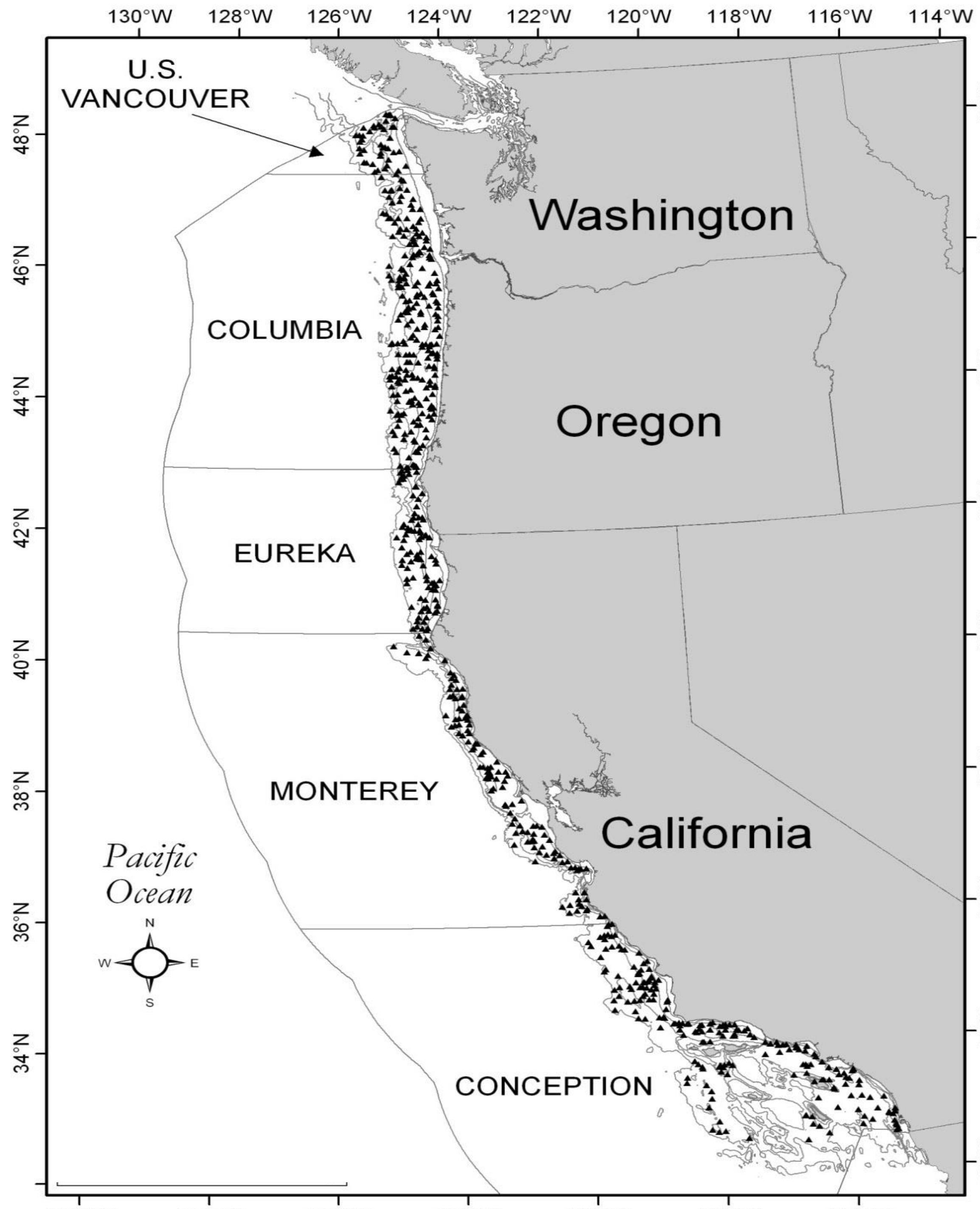

Figure GF1. Example of the number and spatial extent of locations (triangles) surveyed by the West Coast groundfish trawl survey each year during 2003–2010. (Reprinted from Keller et al. 2008.)

FINAL SUITE OF INDICATORS

The list of species for which each indicator will be calculated is located in Table GF5.

ATTRIBUTE 1 -POPULATION SIZE

From the eight indicators in the top quartile for population size, two are used as indicators for population size of groundfish in the CCLME (Table GF6):

CHANGE IN TIME SERIES OF GROUNDFISH BIOMASS

Groundfish biomass was used relative to either the estimate of the unfished biomass from a stock assessment or trends in relative abundance from the survey time series (stock depletion):

a. Tier 1: Modeled estimates of stock depletion based on estimates of spawning biomass from assessments beginning in 2007 as earlier assessments are out of date.

b. Tier 2: Trends in stock depletion based on relative biomass estimates from the NWFSC annual trawl survey.

NUMBER OF ASSESSED SPECIES BELOW MANAGEMENT THRESHOLDS: END YEAR POINT ESTIMATES OF STOCK DEPLETION

Two tiers are specified for biomass of groundfish in as a measure of abundance because stock assessments provide the best available estimates of spawning stock biomass and depletion, integrating all of the available data on each stock over the full exploitation history of each stock, while in the absence of a stock assessment the survey relative biomass index provides the best information available to estimate trends in the stock size, albeit over a shorter time series in comparison to the stock assessments. As stock assessments are generally updated on a 2-6 year cycle, for stock assessments that do not extend beyond 2007 the IEA is providing both the time series of spawning stock biomass from the assessment as well as the trend in biomass from the survey are presented. As hake cannot be monitored for trends via the NWFSC annual bottom trawl survey due to likely annual changes in availability to the survey gear, the hake acoustic relative survey biomass is used as an alternative. The number of species below management thresholds was chosen because it is an easy measure of species or stocks that have typically been doing poorly in the past, but we recognize that documents (Miller et al. 2009) already exist that communicate this information. Thus this indicator may not be necessary in a final status report of the CCLME.

ATTRIBUTE 2 - POPULATION CONDITION

From the five indicators in the top quartile for population condition, one is used as indicators for population condition of groundfish in the CCLME (Table GF6):

METRICS OF POPULATION AGE (OR SIZE IN THE ABSENCE OF AGE) STRUCTURE

a. Tier 1: Modeled estimates of age structure (or size structure in the absence of age) from assessments beginning in 2007 as earlier assessments are out of date.

b. Tier 2: Age structure (or size structure in the absence of age) from the NWFSC annual survey

These indicators are in the top indicators evaluated. Rebuilding timeline was not chosen as one of the final indicators because it is only available for species which have been formally considered overfished; thus it is only useful for a small number of species that are already below the target reference point. Using age structure accounts for many of the ecological processes that would affect age at maturity, so age at maturity is eliminated from the final indicator suite. Where available age structure is used as the indicator; however, size structure has been used in lieu of age structure where age data are not available. Size structure was not in the top quartile for population condition indicators, but it is the top-ranked indicator in the second quartile and missed the top quartile by 0.03 points.

POPULATION AGE OR SIZE STRUCTURE

The mean age or size of all species caught in either fishery-independent surveys, fishery-dependent surveys, or landings is thought to be a useful and simple indicator to evaluate the overall effects of fishing (e.g., changes in rates of mortality) on an ecosystem (Fulton et al. 2005, Link 2005, Coll et al. 2009). Age and size-based metrics respond to fishing impacts because age and body size determines the vulnerability of individuals, populations, and communities (Jennings and Dulvy 2005). Others contend that there are very few examples where length-based analysis leads to useful management advice, in part because of the need for age and gear selectivity information, and because size related changes in distribution will influence data (Hilborn and Walters 1992). Additionally, older individuals tend to be more fecund and some fish species produce larvae that have a higher survival rates than larvae from younger fish (Berkeley 2004b, Bobko and Berkeley 2004). Age and size based metrics are thought to better support medium-term rather than year-to-year management evaluation, because the response to management actions often cannot be quantitatively interpreted for contributing causal factors without extensive additional research (Jennings and Dulvy 2005).

Fish population age and size structure has been linked to scientifically defined reference points or progress targets. Some have based these on a decline in mean size of greater than 30% (warning or precautionary threshold) or greater than 50% (limiting reference point), the latter of which was chosen because it corresponds to an observed doubling in the time series of length after fishing has decreased (Link 2005). Others suggest that practical issues currently preclude the development and adoption of firm reference points for size-based indicators, although an appropriate target would be a reference direction that is consistent with a decline in the overall human impacts of fishing on the community, and thereby on the ecosystem (Jennings and Dulvy 2005). Similar reference points could be defined for mean population age.

The principal attraction of size-based metrics is the widespread availability of species size and abundance data collected during ongoing monitoring programs (Jennings and Dulvy 2005). Many monitoring programs collect a more limited but potentially more informative set of age data. The AFSC triennial survey and NWFSC annual survey have collected size data from a large array of species, and age data from a more limited set of species. The NWFSC annual survey collects up to 100 length measurements, sex determinations, and individual weights, and up to 25 age structures per trawl haul for key species, and more recently for all groundfish species of management concern (Keller et al. 2008). There are well recognized gear-selectivity issues associated with age and size data (Hilborn and Walters 1992) and ideally indicators should be calculated for age and size classes that are well selected by the gear. Fish population age and size structure has been used as an indicator in a variety of other ecosystems, including the Celtic Sea (Blanchard et al. 2005), northeastern U.S. continental shelf (Link and Brodziak 2002), and eastern Bering Sea (AFSC 2009).

Table GF5. List of groundfish for which the aforementioned indicators will be calculated. This list is composed of species in assemblages identified in Cope and Haltuch (2012), species with quantitative stock assessments completed from 2007-2011, and species that are well surveyed by the NWFSC annual trawl survey. Note that due to limited data availability yelloweye rockfish would be removed from this species list without the results of a current stock assessment. Pacific hake would also be removed from this list without a current stock assessment because the trawl survey data alone are subject to changes in hake availability over time. However, as hake is currently assessed every year, hake should remain on the species list.

Species	Scientific name	Assessment Years
Pacific hake	*Merluccius productus*	2007, 2008, 2009, 2010, 2011
Stripetail rockfish	*Sebastes saxicola*	
Sablefish	*Anoplopoma fimbria*	2011
Dover sole	*Microstomus pacificus*	2011
Redstripe rockfish	*Sebastes proriger*	
Splitnose rockfish	*Sebastes diploproa*	2009
Rex sole	*Glyptocephalus zachirus*	
Chilipepper rockfish	*Sebastes goodei*	2007
Spiny dogfish	*Squalus acanthias*	2011
Shortbelly rockfish	*Sebastes jordani*	2007
Arrowtooth flounder	*Atheresthes stomias*	2007
Darkblotched rockfish	*Sebastes crameri*	2007, 2009, 2011
Canary rockfish	*Sebastes pinniger*	2007, 2009, 2011
Lingcod	*Ophiodon elongatus*	2009
Longnose skate	*Raja rhina*	2007
Yelloweye rockfish	*Sebastes ruberrimus*	2007, 2009, 2011
Aurora Rockfish	*Sebastes aurora*	
Blackgill Rockfish	*Sebastes melanostomus*	2011
Bocaccio Rockfish	*Sebastes paucispinis*	2007, 2009, 2011

English Sole	*Parophrys vetulus*	2007
Flathead Sole	*Hippoglossoides elassodon*	
Greenstriped Rockfish	*Sebastes elongatus*	2009
Pacific Ocean Perch	*Sebastes alutus*	2007, 2009, 2011
Pacific Sanddab	*Citharichthys sordidus*	
Petrale Sole	*Eopsetta jordani*	2009, 2011
Spotted Ratfish	*Hydrolagus colliei*	
Yellowtail Rockfish	*Sebastes flavidus*	
Black Rockfish	*Sebastes melanops*	2007
Widow Rockfish	*Sebastes entomelas*	2007, 2009, 2011
Greenspotted Rockfish	*Sebastes chlorostictus*	2011

Table GF6. Top indicators for Attributes 1and 2.

Attribute	Indicator	Definition and source of data	Time series	Sampling frequency
Population Size	Groundfish biomass	Tier 1: Modeled estimates of spawning biomass as measured by stock depletion from assessments beginning in 2007 as methods have been most stable during the 2007 – present. Tier 2: Relative biomass estimates as measured by the trend in the NWFSC annual survey	Tier 1: Variable by species Tier 2: 2003-2011	Annual estimate from both Tier 1 and 2 indicators
Population Size	Number of assessed species below management thresholds	Number of species below the PFMC overfished level and currently subject to rebuilding plans	N/A	Biannual rebuilding analyses
Population Condition	Population age (or size) structure	Tier 1: Modeled estimates of age structure (or size structure in the absence of age) from assessments beginning in 2007 as methods have been most stable during the 2007 – present. Tier 2: Age structure (or size structure in the absence of age) from the NWFSC annual survey	Tier 1: Variable by species Tier 2: 2003-2011	Annual estimate from both Tier 1 and 2 indicators

STATUS AND TRENDS

MAJOR FINDINGS

Stock status (based on biomass trends) and population demographic condition (as measured by proportion mature and of maximum age or size) were summarized for 30 groundfishes. Most assessed groundfishes are above the biomass limit reference point, and are thus not overfished (Figure GF2). The four assessed stocks currently in an overfished state are all rockfishes. All assessed groundfishes are below their target catch, thus overfishing is not occurring in these stocks. Regarding population condition measures, age or length structure tended to show more changes, usually declines, over time than proportion mature. Non-elasmobranch groundfishes tended to see the most changes over time in both measures, with rockfishes being most sensitive to demographic changes.

INDICATOR #1: RELATIVE TRENDS IN BIOMASS TRAJECTORIES

SUMMARY

Biomass trajectories are a commonly used indicator of fisheries population dynamics and show the details of how the population biomass has changed over time. Trends in the time series of abundance smooth out the dynamics to offer a directional summary of the changes. And while absolute biomass trends can be used, it is more common to consider the change in biomass relative to unfished condition, termed "depletion".

A stock in considered more depleted when this ratio is relatively smaller, and less depleted when it is relatively larger. This ratio has particular meaning in groundfish management, where status reference points are based on depletion. For groundfishes other than flatfishes, the target depletion is 40% of unfished levels and the limit reference point (the value under which stocks are considered overfished) is 25% unfished levels. For the flatfishes, the target and limit reference points are 25% and 12.5%, respectively. All subsequent biomass measures are the mature female biomass, also called "spawning biomass", which is the commonly used biomass metric of age-structured stock assessments.

Ideally one would be able to census a population over a long period of time to get a direct measure of stock status for that period. Such detailed population information is not available for any Pacific coast groundfishes, so the next best source of status information is to use the population biomass estimates from age-structured stock assessments. Age-structured stock assessments combined fishery removals, abundance indices, size composition data, and life history information to reconstruct an estimation of how the population biomass changed over time. Barring the availability of stock assessment information, trends in indices of abundance as measured by a fishery-independent survey (specifically, the annual groundfish trawl survey conducted by the Northwest Fisheries Science Center since 2003) were considered. Of the 90+ groundfish species in the groundfish Fishery Management plan, 30 species contain either of these data sources, and thus were considered for status determination. The current development of data-limited methods (Cope 2012; Dick and McCall) may allow more groundfishes to be included in this summary in future iterations of the IEA.

For the analysis of groundfish status, we considered stock assessments from 2007 to 2011 to derive relative biomass trajectories. This was available for 21 of the 30 groundfishes considered. For the remaining 9 stocks, NWFSC trawl survey indices of abundance were used. Stocks with assessments only up until 2007 were also supplemented with the results of the survey abundance. Because the survey indices are limited in temporal coverage, relative trends in abundance rather than depletion are used and the change in index trend compared to the average biomass value and variance over the last 5 years are used instead of depletion reference points. Current population dynamics in the relative biomass trajectories were also evaluated for the last 5 years of the time series. Groundfish stocks were considered in 4 major groups: 1) Elasmobranchs, 2) Flatfishes, 3) Rockfishes and 4) Roundfishes. Within the first three groups, depth was used to distinguish three additional ecological categories: 1) nearshore, 2) shelf, and 3) slope. In general, there are very few nearshore representatives given the lack of assessments of nearshore species and the inadequacy of the trawl survey to sample the nearshore environment, so this status analyses is mostly limited to shelf and slope species. Full time series are provided for each series, but the last 5 years are used to determine the most recent trends.

Overall, most assessed groundfishes are above the biomass limit reference point, and are thus not overfished (Figure GF2). The only assessed stocks currently below the overfished status reference point are all rockfishes. All assessed groundfishes are below their target catch, thus overfishing is not occurring in these stocks. Many of the stocks show biomass around or above the target reference point as well as stable or increasing in the short term (Table GF7). **Elasmobranchs (Figures GF3-GF6;** Table GF7**):** Assessed elasmobranch stocks are all above target depletion levels, while all stocks presented show stable population dynamics over the last 5 years.

Flatfishes (Figures GF7-GF15; Table GF7**):** Two of the three assessed flatfishes were above the target deletion level with one between the target and limit status reference levels. All of the species showed either increasing or stable population dynamics over that past 5 years. The shelf stock represented were either above target and/or demonstrated stable dynamics over the last five years. There is some indication that rex sole is in a slightly downward trend over the last five years, but is currently within the stable limit.

Rockfishes (Figures GF16-GF34; Table GF7**):** All categories of rokfishes show a similar pattern of historical declines with contemporary population increases. Black rockfish (Figure GF16) is the only representative of the nearshore rockfish complex, and it shows a recent increase with the population above the target level. Because of the diversity of life histories and fisheries interactions in the nearshore environment, black rockfish cannot be used as a proxy for the other species. The shelf species also show increasing or steady populations in recent years, though current status ranges from well above the target (greenstriped rockfish; Figure GF24) to well below the limit (cowcod; Figure GF21). Slope species, with generally higher longevities, show a variety of population responses and tend to have status below targeted levels.

Roundfishes (Figures GF35-GF38; Table GF7**):** The roundfishes category is an amalgam of species with very different life histories and adult habitat. The group tend to be at around the target biomass levels with increasing population trajectories, except for sablefish (Figure GF38), which is both below target and trending downward.

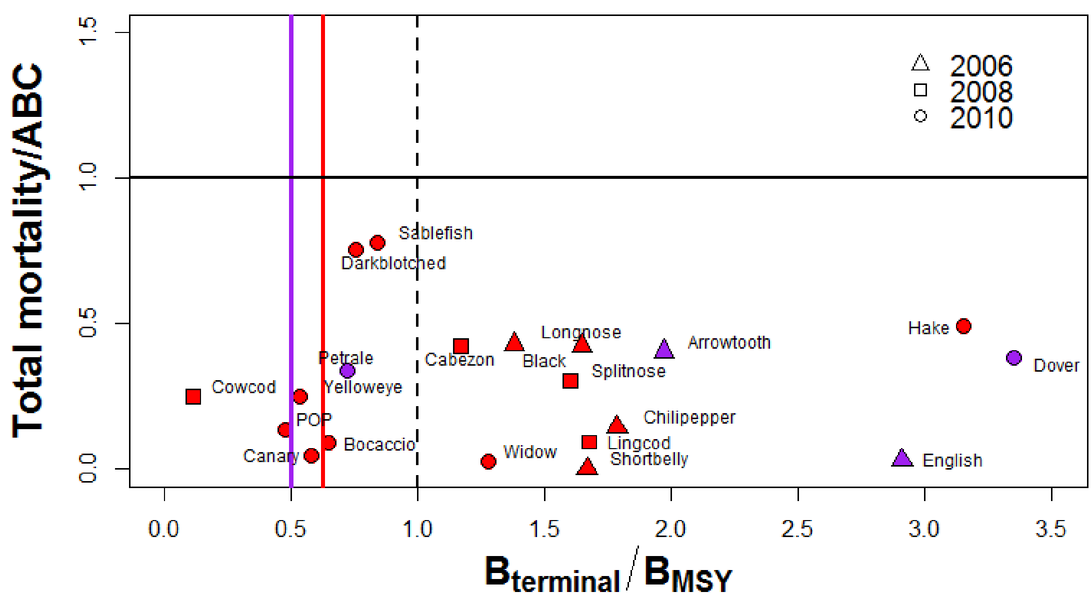

Figure GF2. Stock status plot relative to being overfished (x-axis) and overfishing (y-axis) for all species assessed since 2007. Vertical broken line indicates the target biomass reference point. Vertical solid line indicates the limit reference point indicating an overfished status (red for elasmobranchs, rockfishes, and roundfishes; purple for flatfishes). Horizontal blue line indicates overfishing wherein total mortality exceeds the allowable biological catch (ABC). Symbols indicate the terminal year of the assessment in which the reference points are determined.

Table GF7. Results for each stock evaluated for each of two status indicators: 1) Biomass and 2) Population structure. Two sources of information were used: 1) Stock assessments and 2) Northwest Fisheries Science Center (NWFSC) shelf-slope trawl survey, when assessments were not available, or older than 2007. "Depletion" refers to the relative change in spawning biomass; "5-year trend" is the trend in the last 5 years of the time series (details found in the text). "B final year" is the biomass value in the final year compared to the 5-year average. "Prop. mature" is proportional of the population mature relative to the beginning of the time series; "95% cum." refers to the 95% cumulative age or length of the population relative to the beginning of the time series. +: above target limit or increasing; ●: between target and limit or stable; -: below limit or decreasing. Blank spaces indicate no information reported.

		Biomass				Population structure			
		Assessment		NWFSC Survey		Assessment		NWFSC Survey	
Taxa	Stock	Depletion	5-yr trend	B final year	5-yr trend	Prop. mature	95% cum. age	Prop. mature	95% cum. lt.
Elasmobranch	Longnose skate	+	●	●	●	●	-	●	●
	Spiny dogfish	+	●			●	-		
	Spotted ratfish			●	●			+	●
Flatfishes	Arrowtooth flounder	+	+	●	+	-	-	-	-
	English sole	+	+	●	●	+	-	-	●
	Pacific sanddab			●	+			●	●
	Petrale sole	●	●			-	-		
	Dover sole	+	●			●	●		
	Flathead sole			●	●			●	●
	Rex sole			●	-			●	●
Rockfishes	Black	+	+			-	-		
	Bocaccio	●	●			-	-		
	Canary	-	●			-	-		
	Chilipepper	+	●	●	●	●	-	-	+
	Cowcod	-	●			-	-		
	Darkblotched	●	+			-	-		
	Greenspotted	●	+			-	-		
	Greenstriped	+	+			●	-		
	Pacific Ocean perch	-	●			-	-		
	Redstriped			+	●			-	●
	Shortbelly			●	●			●	●
	Stripetail			●	●			●	●
	Widow	+	+			●	-		
	Yellowtail			●	●			●	●
	Aurora			-	-			-	●
	Blackgill	●	●			-	-		
	Splitnose	+	+			-	-		
	Yelloweye	-	●			-	-		
Roundfishes	Cabezon	+	+			-	-		
	Lingcod	+	+			-	-		
	Pacific Hake	+	+						
	Sablefish	●	-			●	●		

SPECIFIC TIME SERIES

<u>Interpreting biomass time series plots:</u> Green area is above relative target spawning biomass, red is below the limit relative target spawning biomass, and yellow is between the target and limit values. Gray shaded area indicates the last 5 years. Significant population increases were defined as more than 1% per year, while significant decreases were less than 1% a year. No change was less than 1% either way per year. A 1% threshold was chosen arbitrarily and would lead to a minimum of a 10% increase in a decade's time. An up-arrow, down-arrow, and dot indicate increasing, decreasing, and stable population dynamics over the last 5 years, respectively, for the stock assessment derived data. For the shorter survey data time series, two different measures of relative change and trend are used. The mean (solid line) and +/- 1 standard deviation (broken lines) for the full time series is calculated and shown in green. A linear trend is fit to the last five years and the change in biomass over that trend is compared to 1 standard deviation from the mean. Arrows up, down, or level indicate increasing, decreasing, or steady trends, respectively. The average biomass for the last 5 years is also calculated and compared to the full time series mean. A plus or minus indicates a change greater than 1 standard deviation from the full time series mean in either the positive or negative direction, while a dot indicates a change smaller than 1 standard deviation.

Elasmobranchs (N=3)

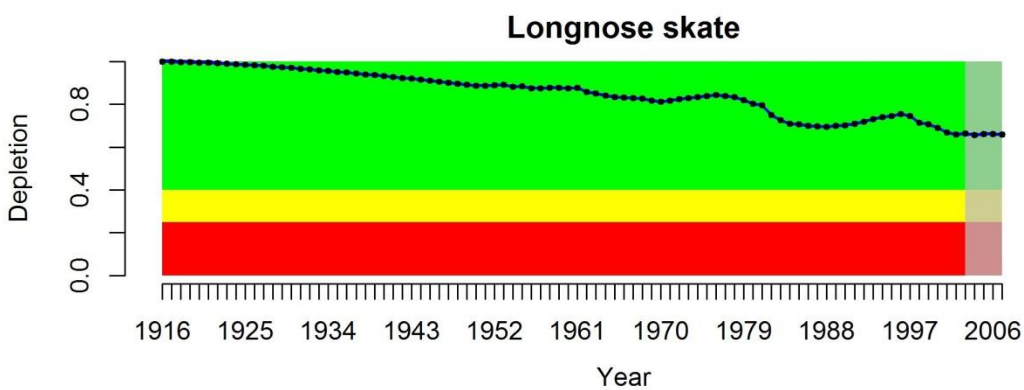

Figure GF3. Relative abundance trajectory 1916-2007 for longnose skate.

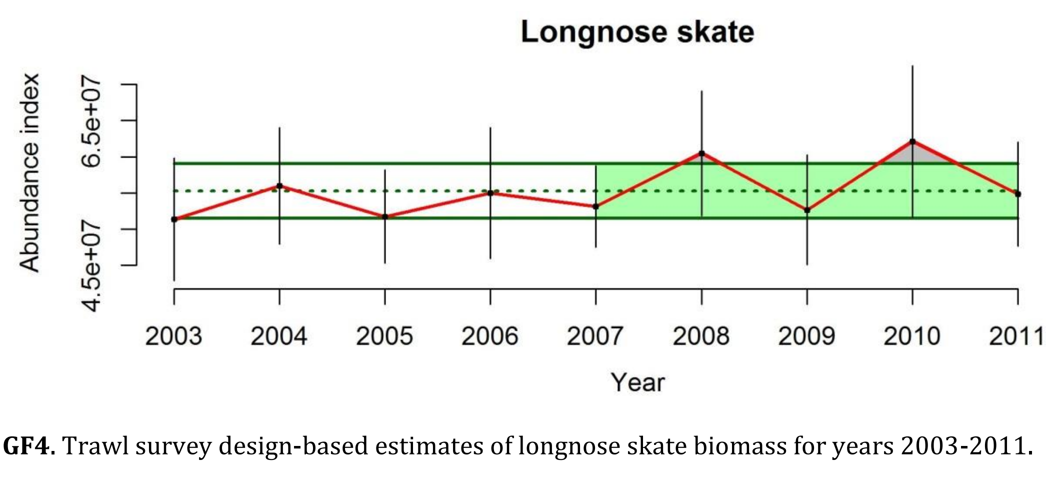

Figure GF4. Trawl survey design-based estimates of longnose skate biomass for years 2003-2011.

Summary: Longnose skate has shown a slow decline over the length of the time series, but with stable population dynamics in the most recent 5 years. Relative biomass appears to have maintained a level above the target biomass in all years.

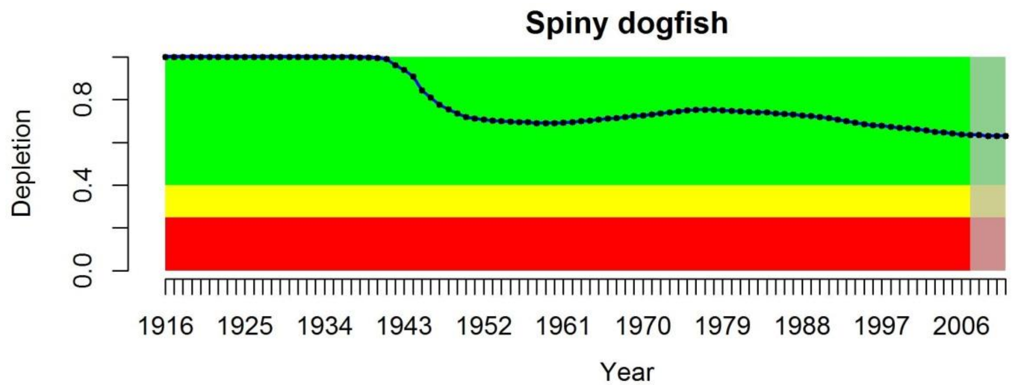

Figure GF5. Relative abundance trajectory 1916-2011 for spiny dogfish.

Summary: After an initial steep decline in the 1940s, relative spiny dogfish abundance has slowed in decline or remained stable in recent years. The population appears to have been above the target relative biomass reference point in all years.

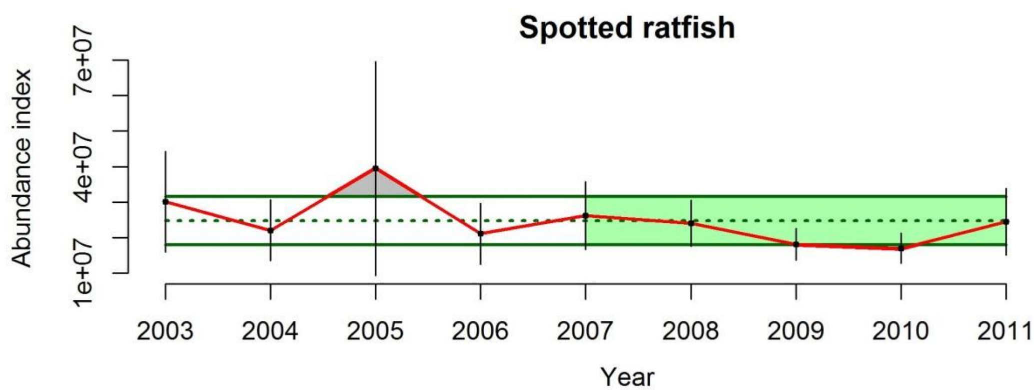

Figure GF6. Trawl survey design-based estimates of spotted ratfish biomass for years 2003-2011.

Summary: No stock assessment for spotted ratfish is available, so no baseline information can be interpreted for this stock at this time. For the most recent years, spotted ratfish appear to have a stable population abundance.

Flatfishes (N=7)

Shelf

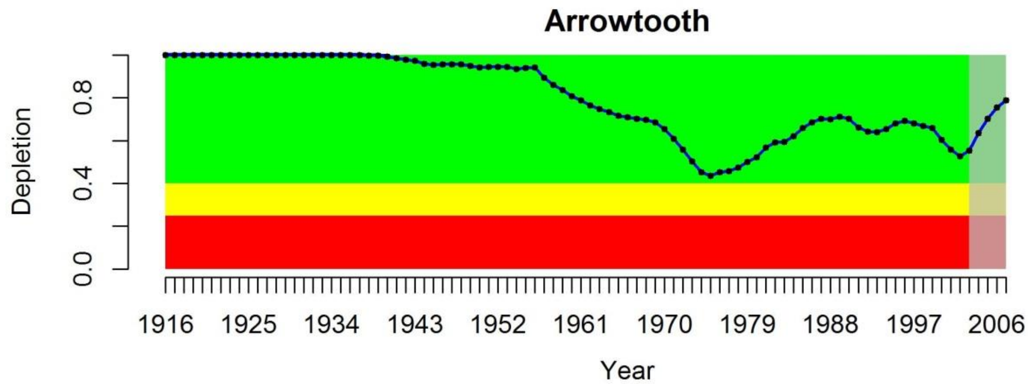

Figure GF7. Relative abundance trajectory 1916-2007 for arrowtooth flounder.

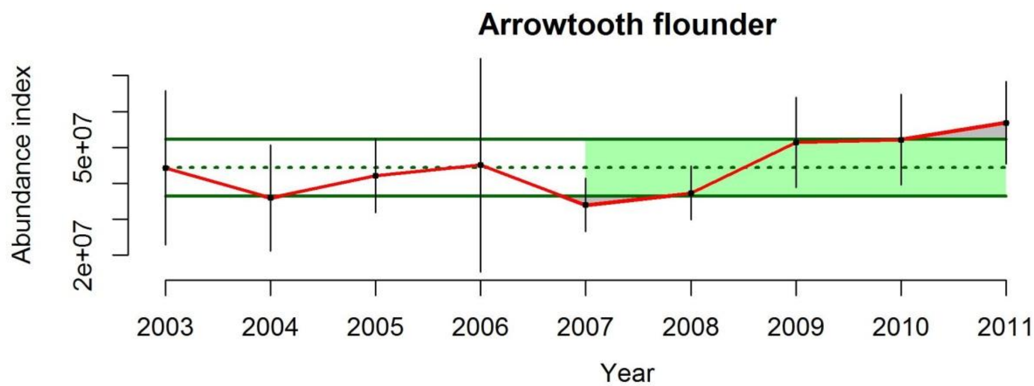

Figure GF8. Trawl survey design-based estimates of arrowtooth flounder biomass for years 2003-2011.

Summary: Arrowtooth flounder demonstrated its greatest decline from the 1950s to the 1970s. It has since increased and continues to show increase in the most recent years. At no point has it been recorded to have gone below the target relative biomass.

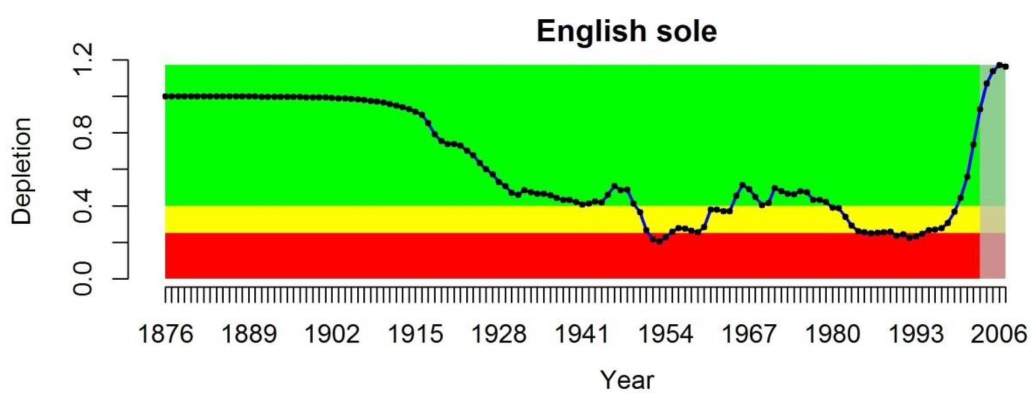

Figure GF9. Relative abundance trajectory 1876-2007 for English sole.

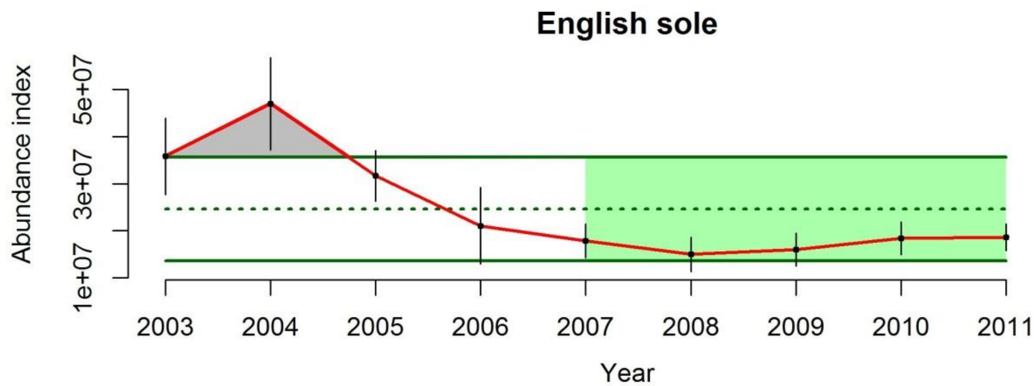

Figure GF10. Trawl survey design-based estimates of English sole biomass for years 2003-2011.

Summary: English sole demonstrated large declines in the early 20th-century, at times dropping below the target relative biomass level. Recent years indicate a large increase, with an increasing or stabilizing trend in the last 5 years.

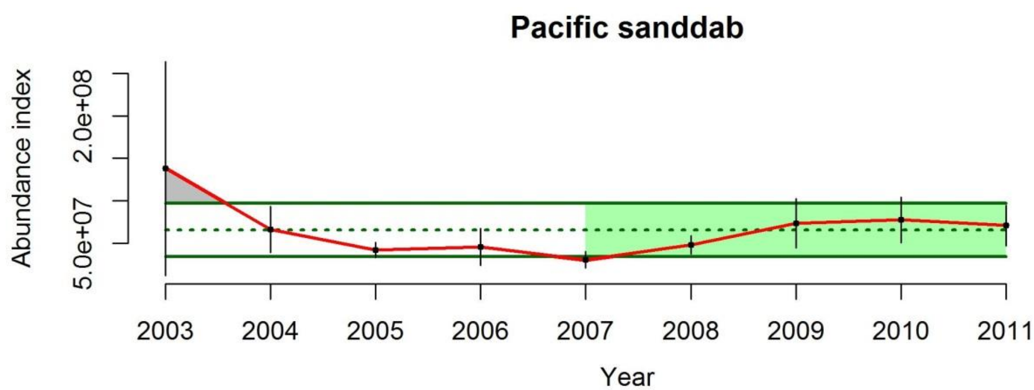

Figure GF11. Trawl survey design-based estimates of English sole biomass for years 2003-2011.

Summary: No stock assessment is available for Pacific sanddab, so no baseline information on abundance exists. Recent years indicate an increasing trend in survey abundance.

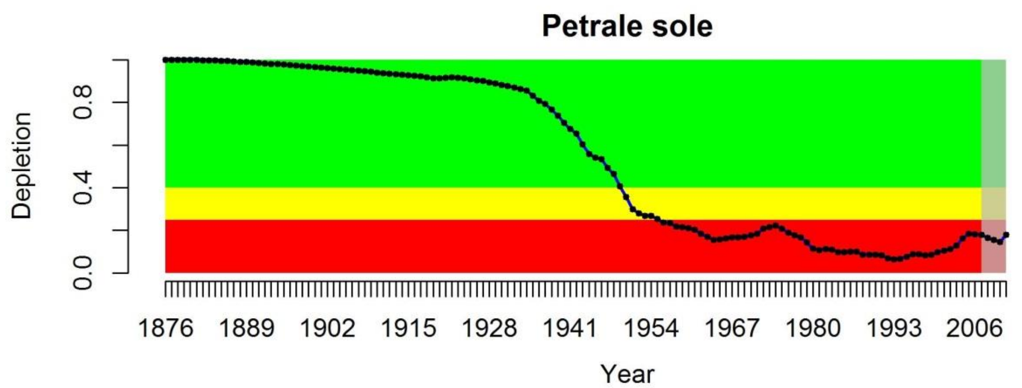

Figure GF12. Relative abundance trajectory 1876-2011 for Petrale sole.

Summary: Petrale sole abundance dropped sharply from the late 1930s to the 1950s, with a steady decline through the 1990s, bring the population below the relative biomass limit. Recent years have shown an uptick with a steady population over the last 5 years.

Slope

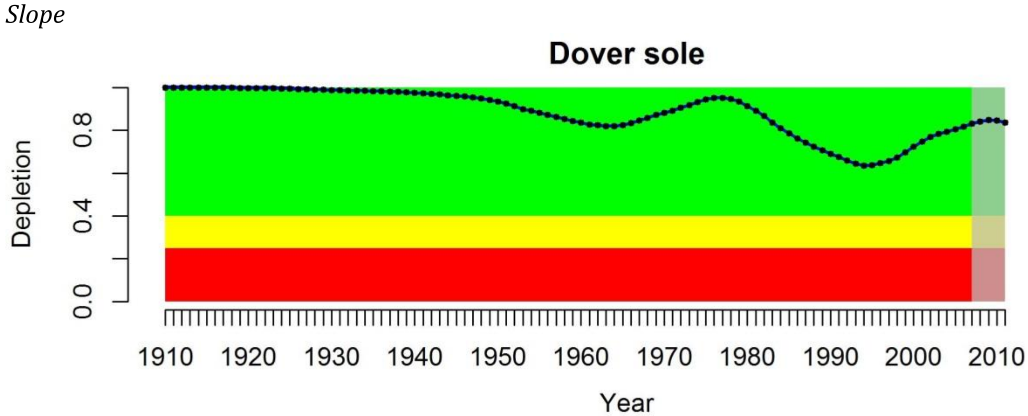

Figure GF13. Relative abundance trajectory 1910-2011 for Dover sole.

Summary: Dover sole populations have shown only slight declines over the time series. Relative biomass has stayed above target levels in all years and is steady over the last 5 years.

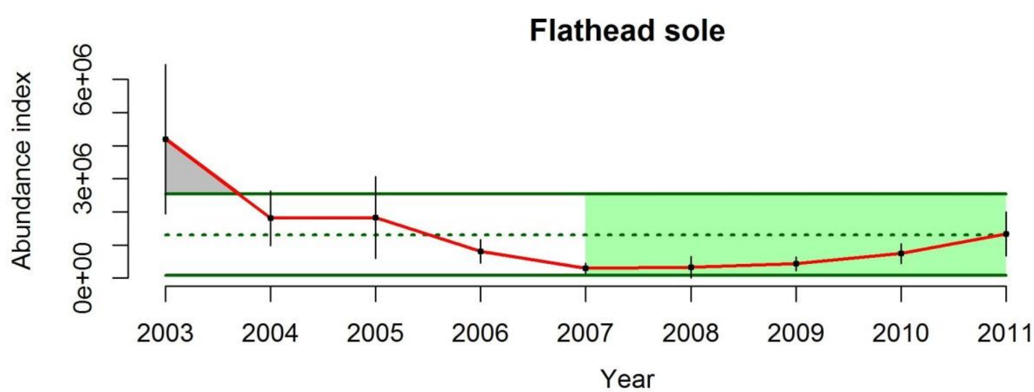

Figure GF14. Trawl survey design-based estimates of flathead sole biomass for years 2003-2011.

Summary: No flathead sole assessment is available, so no baseline information on abundance exists. Recent years indicate a steady trend in survey abundance.

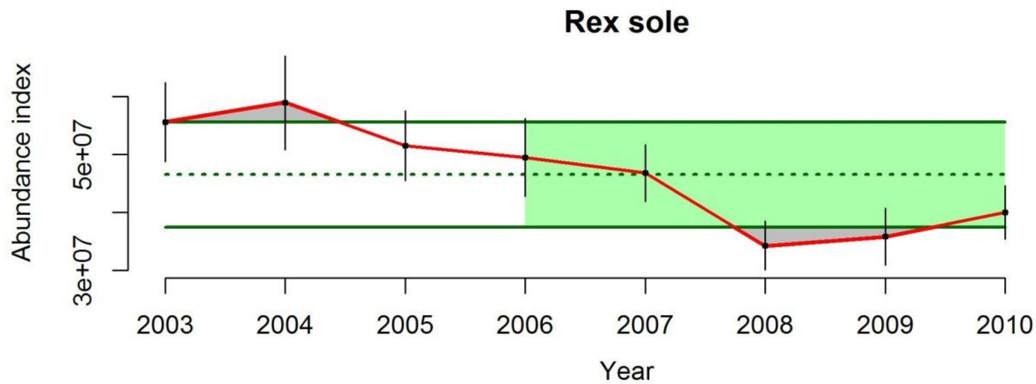

Figure GF15. Trawl survey design-based estimates of English sole biomass for years 2003-2011.

Summary: No rex sole assessment is available, so no baseline information on abundance exists. Recent years indicate a declining trend in survey abundance.

Rockfishes (N=18)

Nearshore

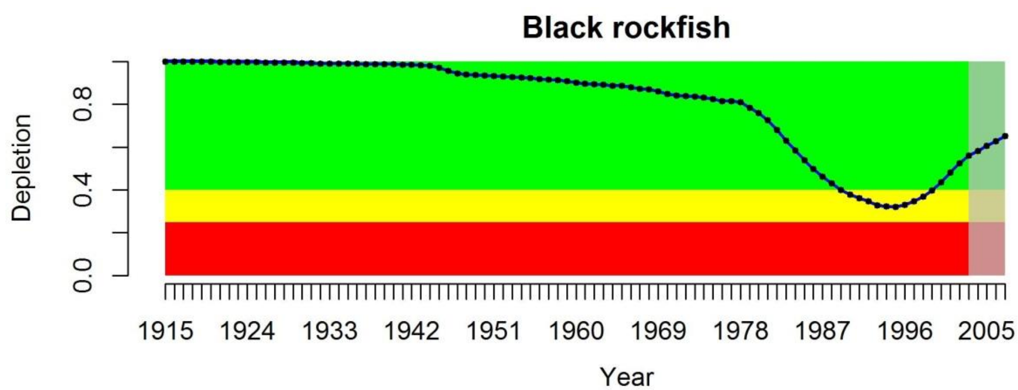

Figure GF16. Relative abundance trajectory 1916-2009 for black rockfish.

Summary: Black rockfish shows a consistent decline until the late 1990s, where in the population starts to grow. Relative biomass dropped below the target relative biomass level for most of the 1990s. Recent years show an increasing trend in population abundance.

Shelf

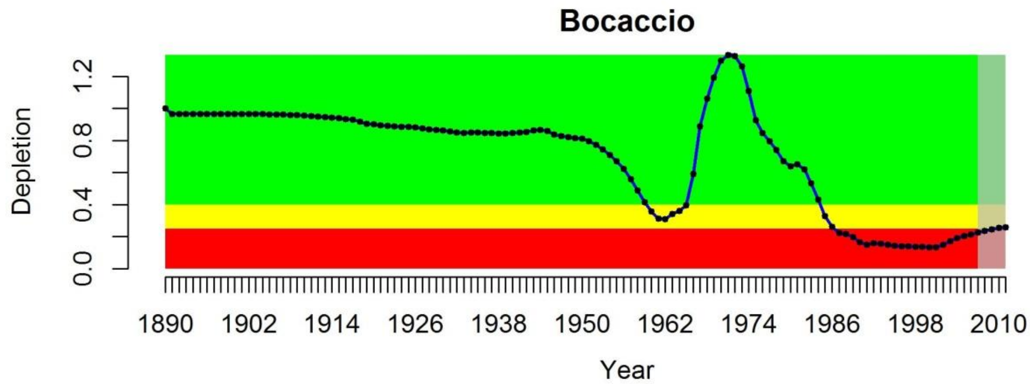

Figure GF17. Relative abundance trajectory 1890-2011 for bocaccio.

Summary: Bocaccio abundance has been highly dynamic over the time series, dropping to levels below the relative biomass limit in recent years. The population trend over that last 5 years is steady.

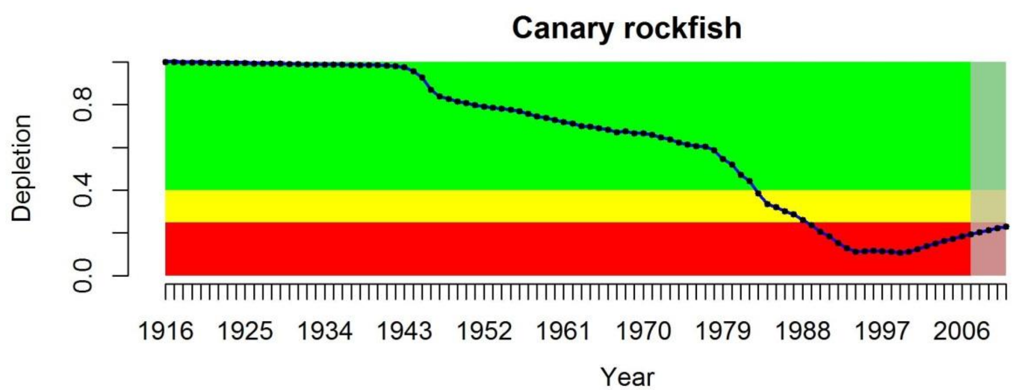

Figure GF18. Relative abundance trajectory 1916-2011 for canary rockfish.

Summary: Large declines in population abundance have been witnessed in canary rockfish, enough to drop the relative abundance below the relative biomass limit. Recent years show very slow growth and an overall stable population.

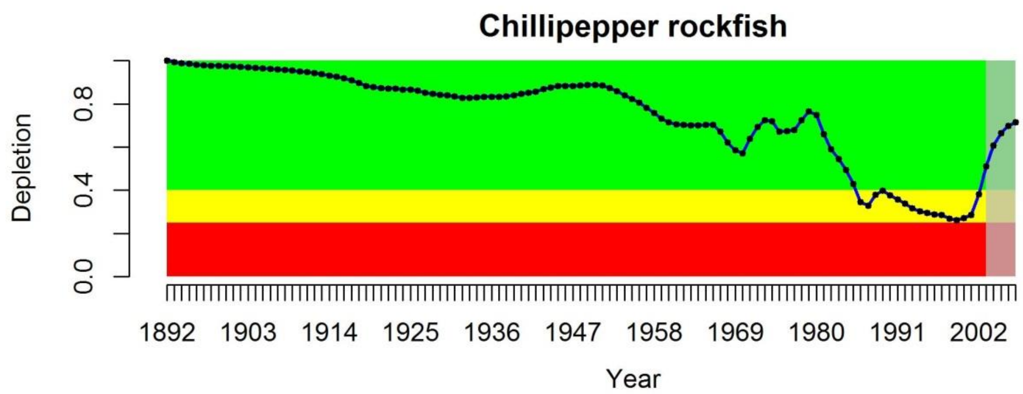

Figure GF19. Relative abundance trajectory 1892-2011 for chilipepper.

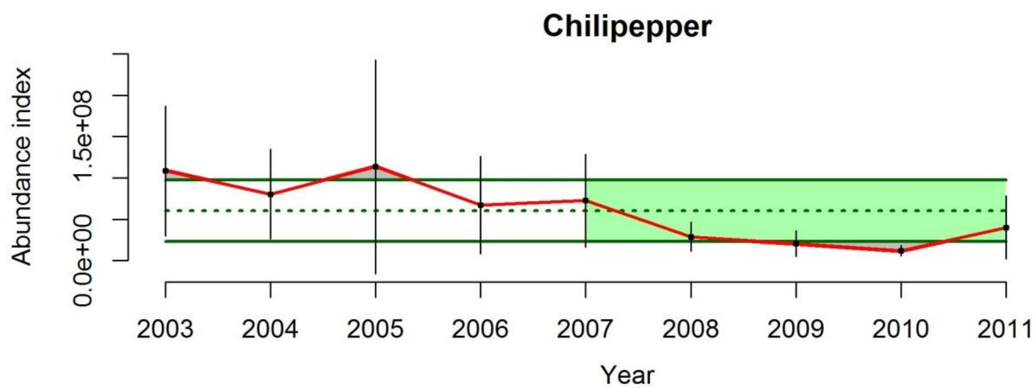

Figure GF20. Trawl survey design-based estimates of chilipepper biomass for years 2003-2011.

Summary: Chilipepper biomass declined below the relative biomass target limit after 1980, then increased substantially in the 2000s. The shor-term trawl survey information indicates a stable population in recent years.

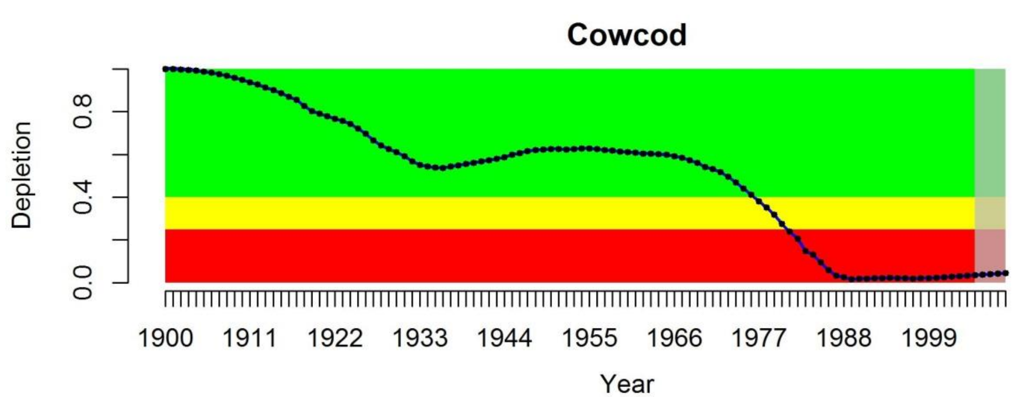

Figure GF21. Relative abundance trajectory 1900-2011 for cowcod.

Summary: Cowcod relative biomass is well below the limit reference point and has very slow growth in recent years, indicating a stable, but low population in recent years.

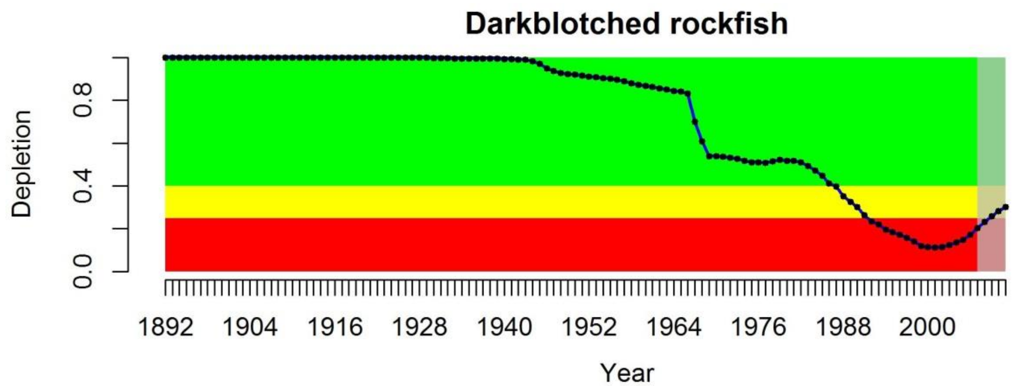

Figure GF22. Relative abundance trajectory 1910-2011 for darkblotched rockfish.

Summary: Darkblotched rockfish showed historical declines in population below relative biomass limits, but recent years show population increase above the limit.

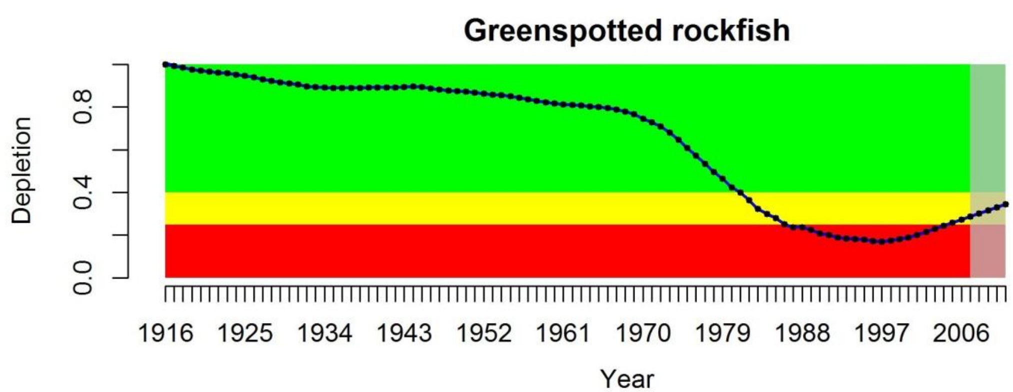

Figure GF23. Relative abundance trajectory 1916-2011 for greenspotted rockfish.

Summary: Greenspotted rockfish abundance historically dropped below the limit reference point, but is recently increasing and near the target relative biomass level.

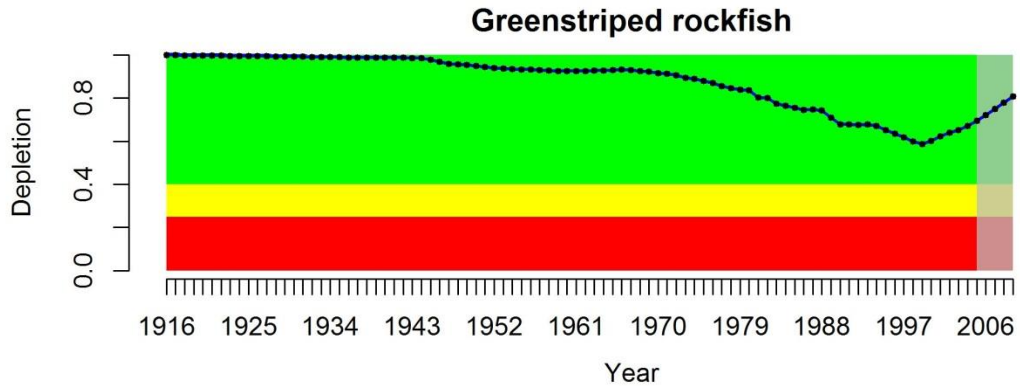

Figure GF24. Relative abundance trajectory 1910-2011 for greenstriped rockfish.

Summary: Greenstriped rockfish has stayed above the target relative biomass level with increasing biomass in the most recent years.

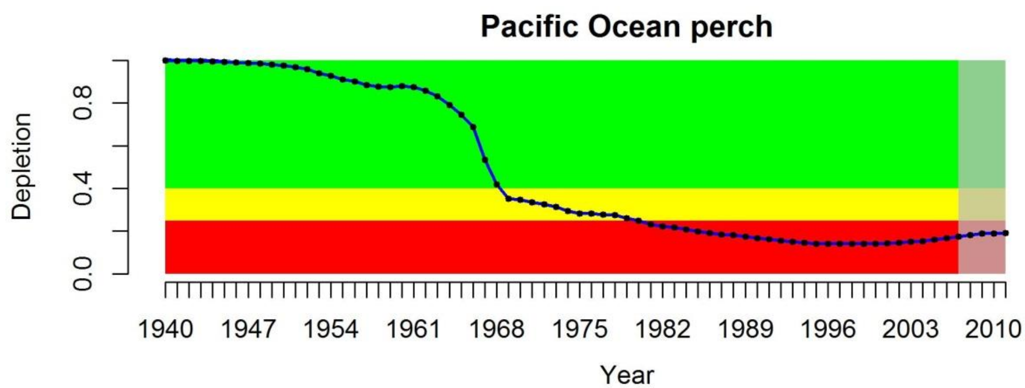

Figure GF25. Relative abundance trajectory 1940-2011 for Pacific Ocean perch.

Summary: Pacific Ocean perch biomass has shown a large historical decline and is currently below the relative biomass limit, though the population is steady in the most recent years.

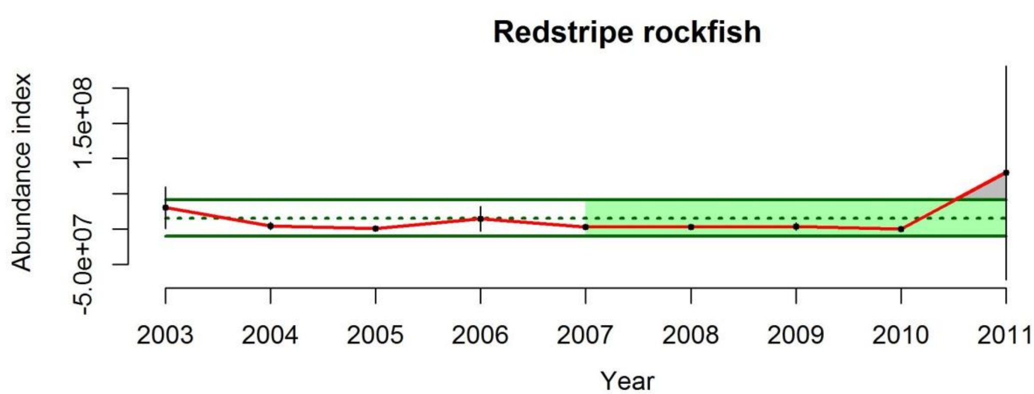

Figure GF26. Trawl survey design-based estimates of restripe rockfish biomass for years 2003-2011.

Summary: No redstripe rockfish assessment is available, so no baseline information on abundance exists. Recent years indicate a stable trend in survey abundance (the last relatively high point has large uncertainty).

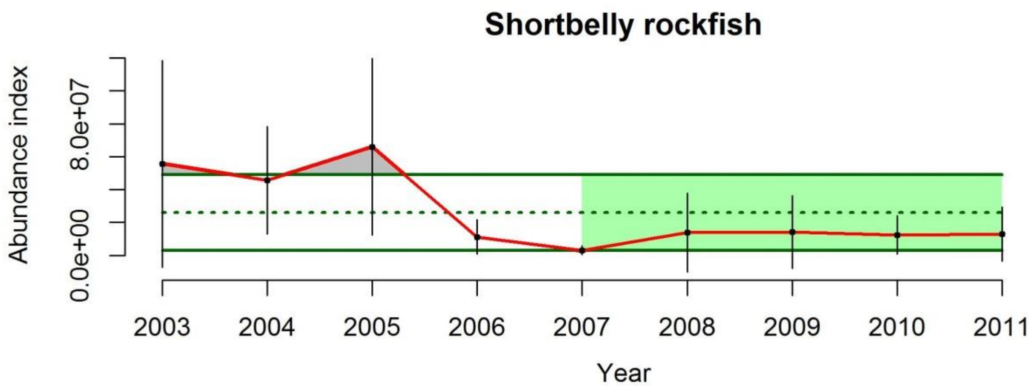

Figure GF27. Trawl survey design-based estimates of shortbelly rockfish biomass for years 2003-2011.

Summary: No shortbelly rockfish assessment is available, so no baseline information on abundance exists. Recent years indicate a stable trend in survey abundance.

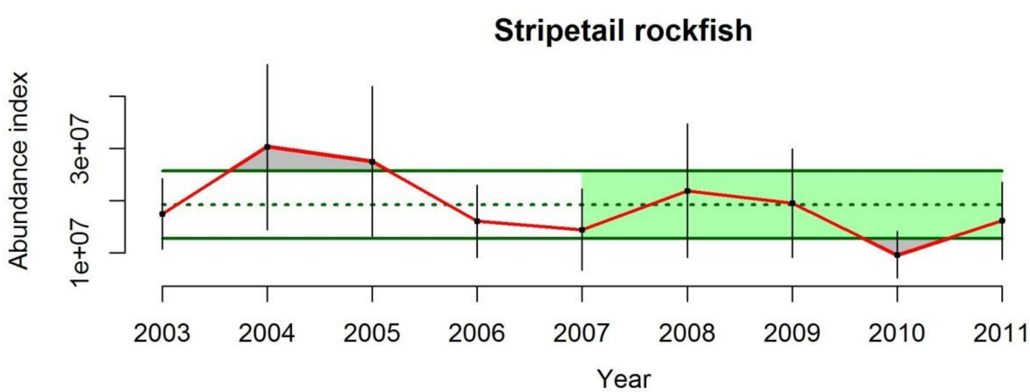

Figure GF28. Trawl survey design-based estimates of stripetail rockfish biomass for years 2003-2011.

Summary: No stripetail rockfish assessment is available, so no baseline information on abundance exists. Recent years indicate a stable trend in survey abundance.

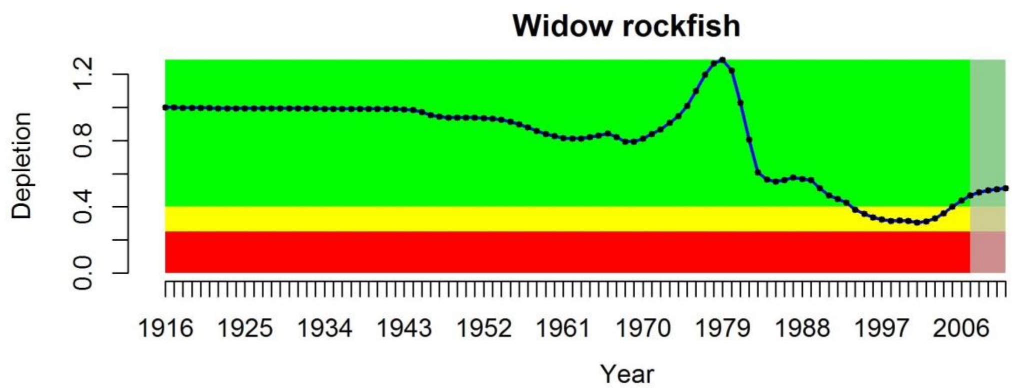

Figure GF29. Relative abundance trajectory 1916-2011 for widow rockfish.

Summary: Widow rockfish historically declined to below the target relative biomass level, but is currently increasing and is above the target.

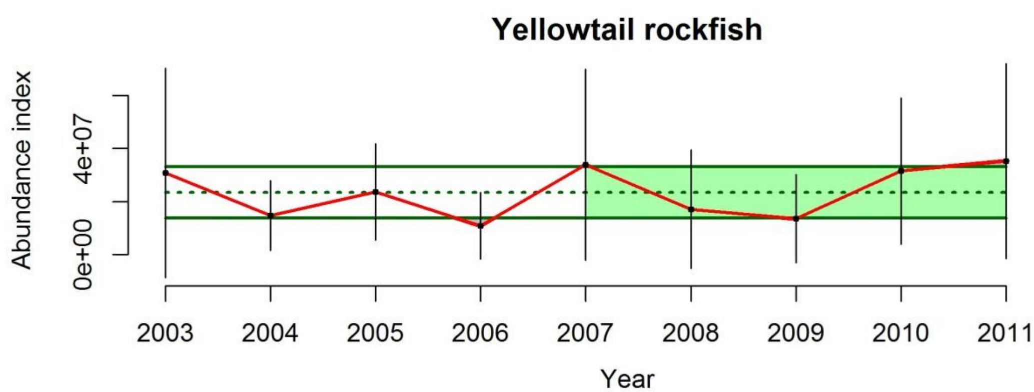

Figure GF30. Trawl survey design-based estimates of yellowtail rockfish biomass for years 2003-2011.

Summary: No yellowtail rockfish assessment is available, so no baseline information on abundance exists. Recent years indicate a stable trend in survey abundance.

Slope

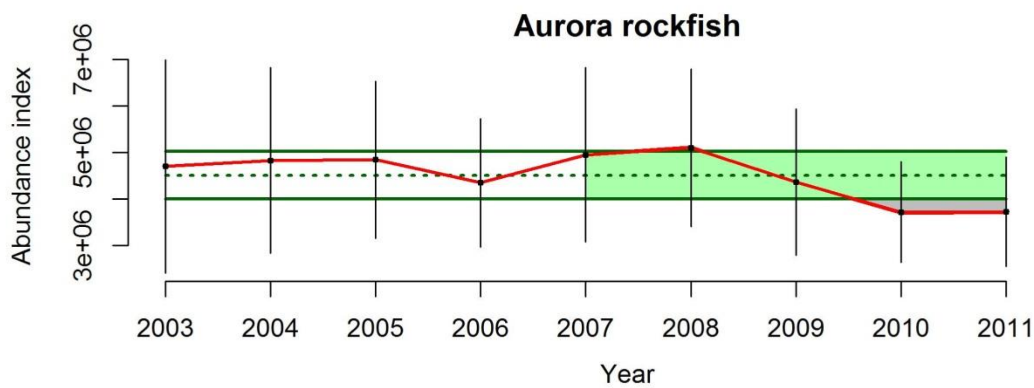

Figure GF31. Trawl survey design-based estimates of aurora rockfish biomass for years 2003-2011.

Summary: No aurora rockfish assessment is available, so no baseline information on abundance exists. Recent years indicate a declining trend in survey abundance.

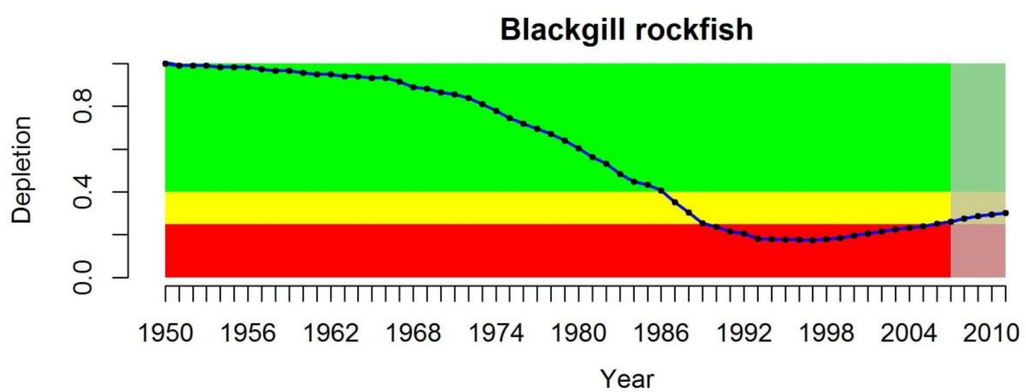

Figure GF32. Relative abundance trajectory 1950-2011 for Dover sole.

Summary: Blackgill rockfish show a historical decline below the limit relative abundance reference point with a slight increase over the last 10 years. The last 5 years show a stable population.

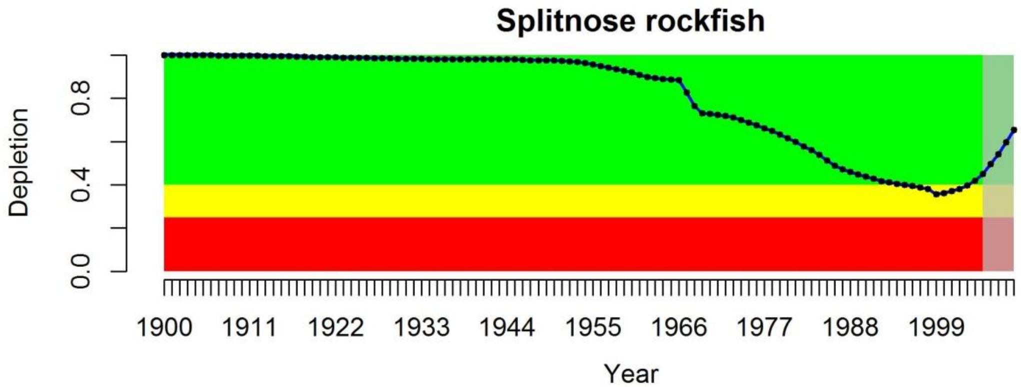

Figure GF33. Relative abundance trajectory 1910-2011 for Dover sole.

Summary: The splitnose rockfish population declined to below the target relative biomass in the late 1990s, but are currently increasing.

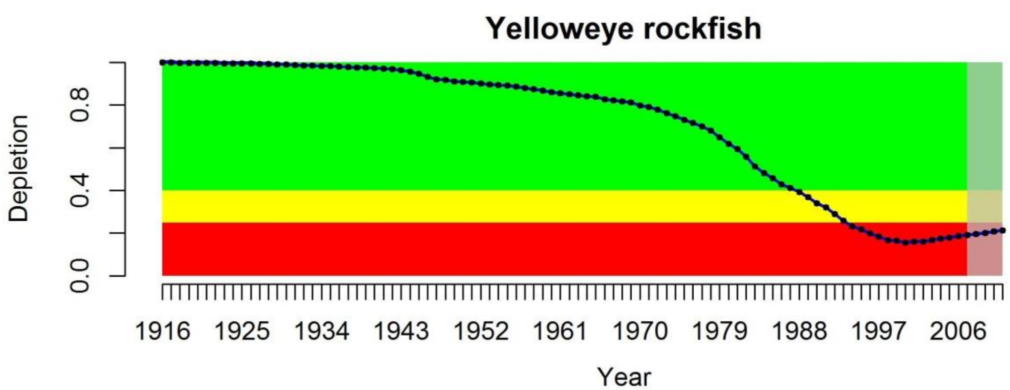

Figure GF34. Relative abundance trajectory 1916-2011 for yelloweye rockfish.

Summary: Yelloweye rockfish declined to below the limit relative biomass level and has stayed below since. Currently, the population is stable.

Roundfishes (N=4)
Nearshore

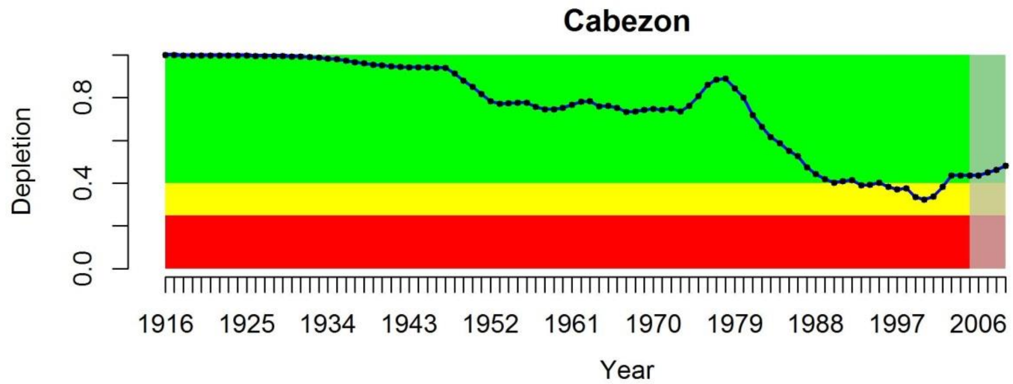

Figure GF35. Relative abundance trajectory 1910-2011 for cabezon.

Summary: Cabezon biomass had declined over the time series to below the relative biomass target level, but has since increased over the most recent years.

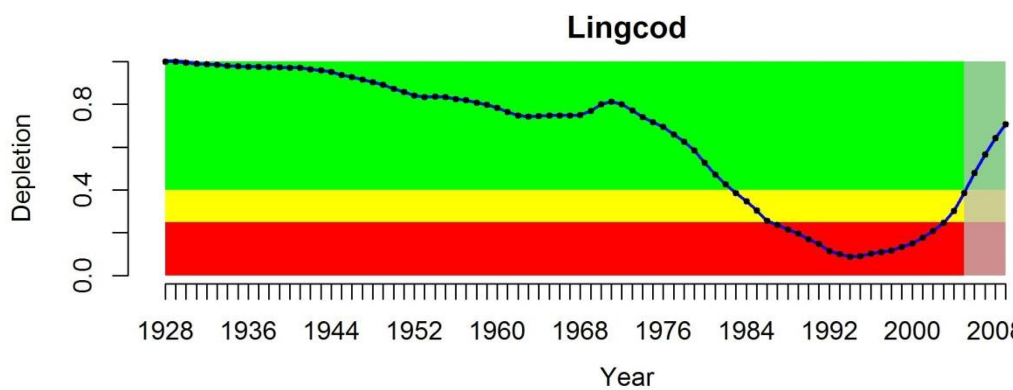

Figure GF36. Relative abundance trajectory 1910-2011 for lincod.

Summary: Lingcod biomass had declined over the time series to below the relative biomass limit reference point, but has since increased over the most recent years.

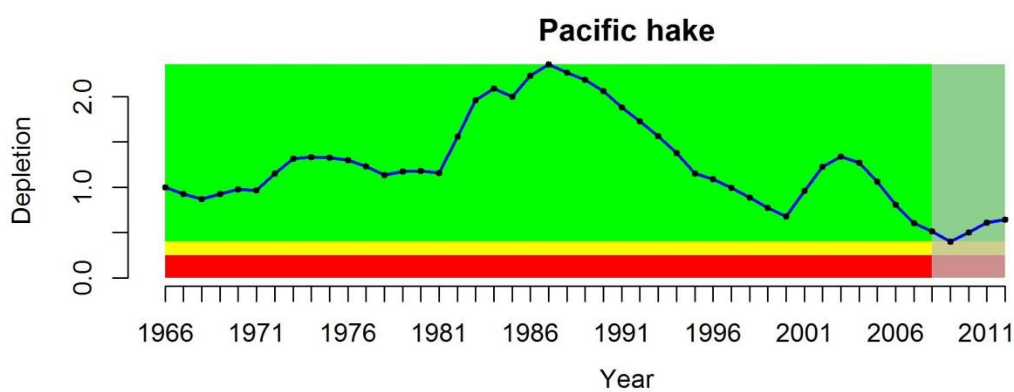

Figure GF37. Relative abundance trajectory 1910-2011 for Pacific hake.

Summary: Pacific hake biomass is very dynamic and is currently above the target relative biomass reference point with a recent increasing biomass trend.

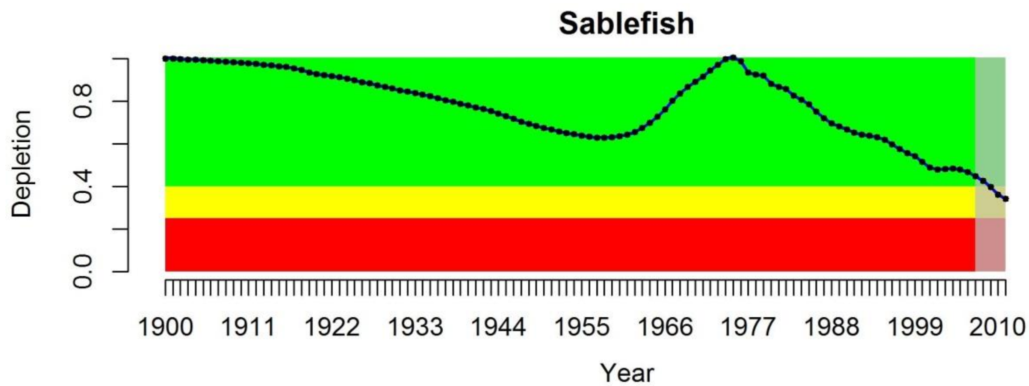

Figure GF38. Relative abundance trajectory 1910-2011 for sablefish.

Summary: Sablefish biomass is very dynamic and is currently below the target relative biomass reference point with a recent decreasing biomass trend.

INDICATOR #2: AGE AND LENGTH STRUCTURE

SUMMARY

The first indicator used female mature biomass as a status indicator, but biomass is made up of individuals with important characteristics such as age, size, and maturity status. This demographic structure of the stock is the second set of groundfish status indicators employed. Proportion maturity gives the percent of the population mature in a given year. The 95% age or length cumulative value indicates at which age or length 95% of the population is below, and thus is a measure of age/length truncation or expansion. All of the above values can be compared to the earliest value in the time series to indicate if they have changed over time. Female age and lengths are used exclusively to be comparable to the spawning biomass in the abundance trends indicator.

As with biomass, stock assessments are used as the primary source of information for maturity and age structure. If no stock assessment was available, trawl survey length compositions were used. Analyses of stocks with stock assessment from 2007 were also supplemented by the trawl length compositions. The same species grouping as used in the abundance indicators are also used to organize stock results.

Overall, age or length structure tended to show more changes over time than proportion mature (Table GF7). Long-term time series comparisons generally showed declines in these indicators, whereas short-term comparisons demonstrated more stability (Table GF7), suggested most change happened earlier in the fishery histories of these stocks. Non-elasmobranch groundfishes tended to see the most changes over time in both measures, with rockfishes being most sensitive to demographic changes (Table GF7). And though it reasonable to expect these age/length-based indicators to be sensitive to yearly recruitment fluctuations, particularly large recruitments, changes in these indicators seemed more consistent with declines in spawning biomass, and thus deeper population structure changes, than recruitment variability.

Elasmobranchs (Figures GF39-GF42; ; Table GF7**):** Age or length structure showed little change in these elasmobranchs, but maturity did change in species with long time series. All measures were stable in the most recent years.

Flatfishes (Figures GF43-GF51; Table GF7**):** Flatfishes in the shelf showed decreases over time in both measures, while the deeper slope species showed little change over time in either measure.

Rockfishes (Figures GF52-GF70; Table GF7**):** Rockfishes showed a general decline in both measures through time, regardless of the adult habitat. Chilipepper was the one exception, which shows little change over the entire time series. Greenstriped (Figure GF60) and widow rockfish (Figure GF65) show contemporary measures have increased near initial conditions after historical declines. Stripetail (Figure GF64) and yellowtail rockfish (Figure GF66) show little change in the trawl survey lengths, but there is no historical baseline to interpret these values. Overall, rockfishes were the most sensitive species group to demographic changes.

Roundfishes (Figures GF71-GF73; Table GF7**):** Two of three roundfishes (cabezon and lingcod, both shallow egg-layers with nest-guarding males) showed declines in both measures, whereas sablefish showed little change over time. Lingcod has shown recent increases in both measures.

SPECIFIC TIME SERIES

Elasmobranchs (N=3)

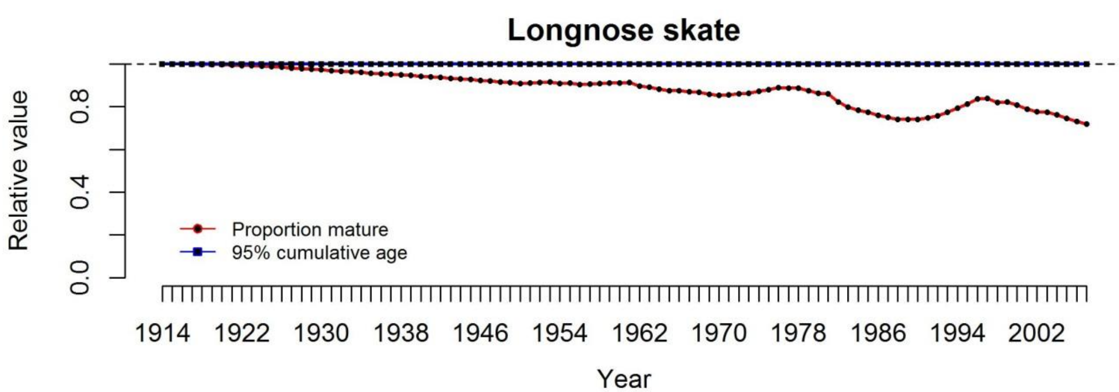

Figure GF39. Proportion of the longnose skate population mature (red) and at the 95% cumulative age (blue) relative to the first year (1916) of the time series.

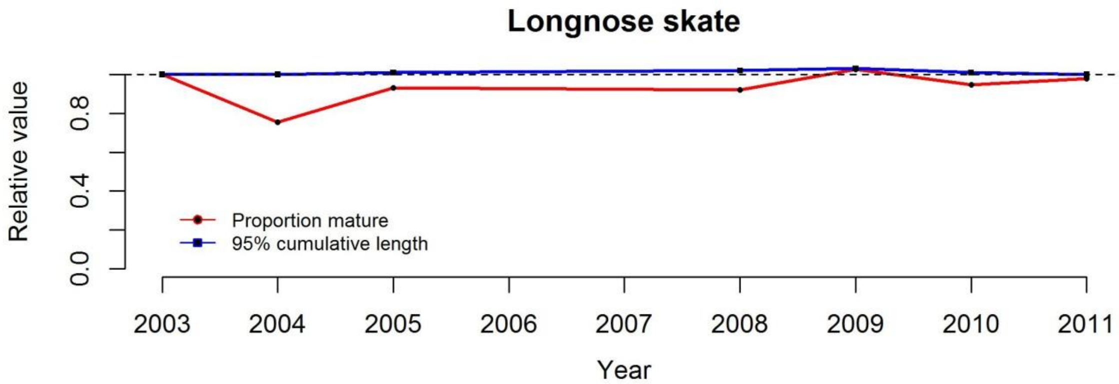

Figure GF40. Proportion of the longnose skate population mature (red) and at the 95% cumulative length (blue) relative to the first year (2003) of the trawl survey time series.

Summary: Longnose skate have shown no decline in the proportion of the oldest ages and largest lengths, but proportion mature has declined somewhat over the length of the time series.

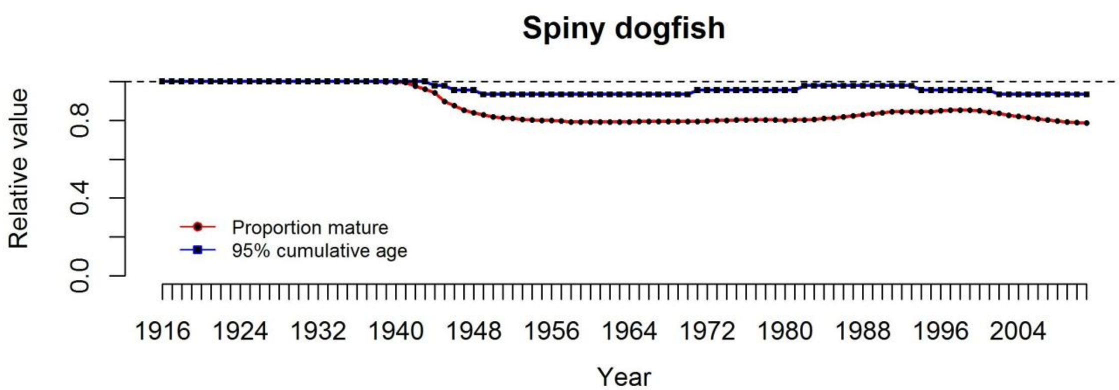

Figure GF41. Proportion of the spiny dogfish population mature (red) and at the 95% cumulative age (blue) relative to the first year (1916) of the time series.

Summary: Spiny dogfish show only small declines in proportion mature and proportion of the oldest ages that have mostly stabilized since the decline in the 1940s.

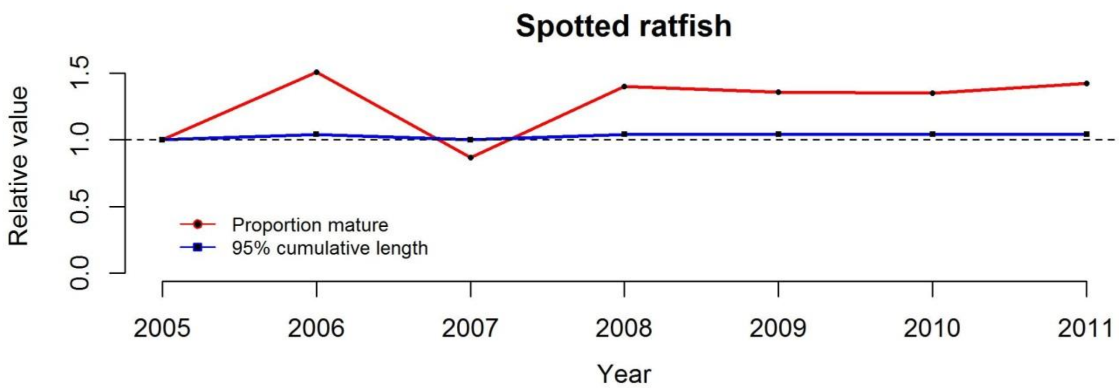

Figure GF42. Proportion of the spotted ratfish population mature (red) and at the 95% cumulative length (blue) relative to the first year (2005) of the trawl survey time series.

Summary: No stock assessment is available for spotted ratfish so no baseline information on demographic structure is available. No declines in either maturity or proportion of the largest sizes are apparent from the trawl survey data.

Flatfishes (N=7)

Shelf

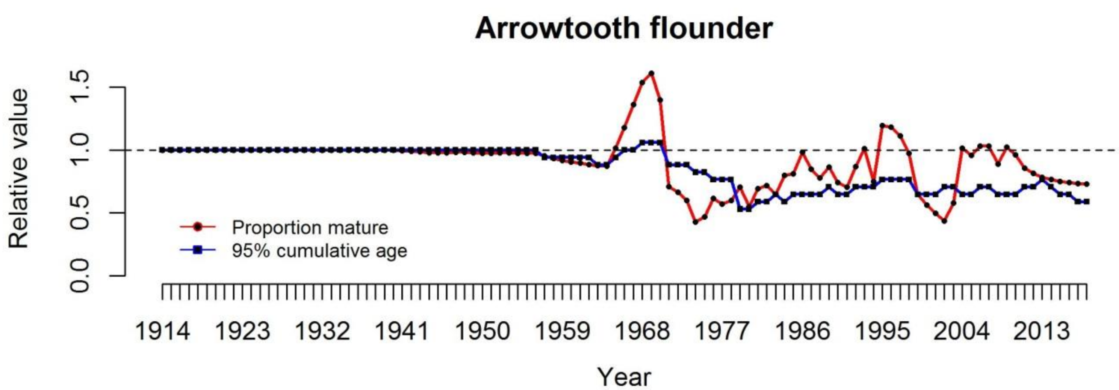

Figure GF43. Proportion of the arrowtooth flounder population mature (red) and at the 95% cumulative age (blue) relative to the first year (1916) of the time series.

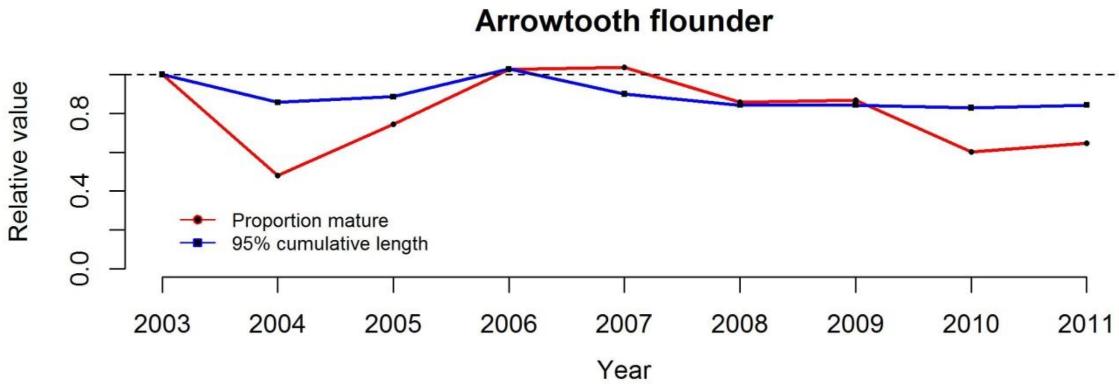

Figure GF44. Proportion of the arrowtooth flounder population mature (red) and at the 95% cumulative length (blue) relative to the first year (2003) of the trawl survey time series.

Summary: Arrowtooth flounder show declines in proportion mature and proportion of the oldest ages and largest lengths over the length of the time series.

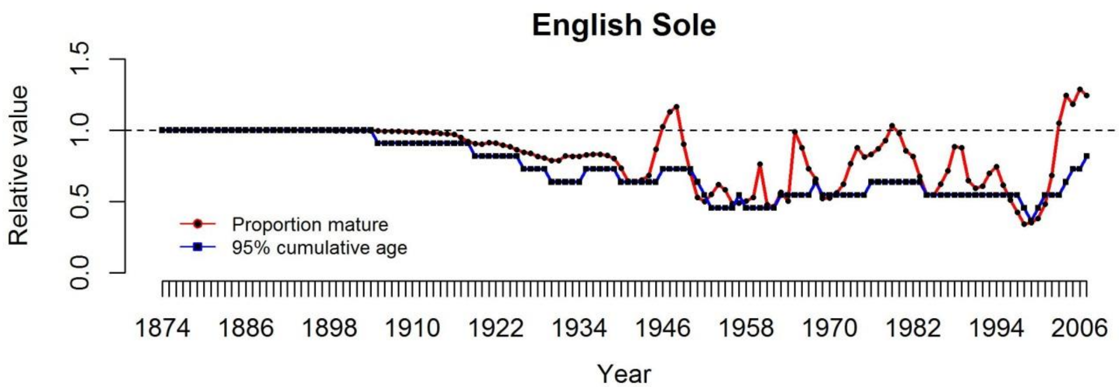

Figure GF45. Proportion of the English sole population mature (red) and at the 95% cumulative age (blue) relative to the first year (1876) of the time series.

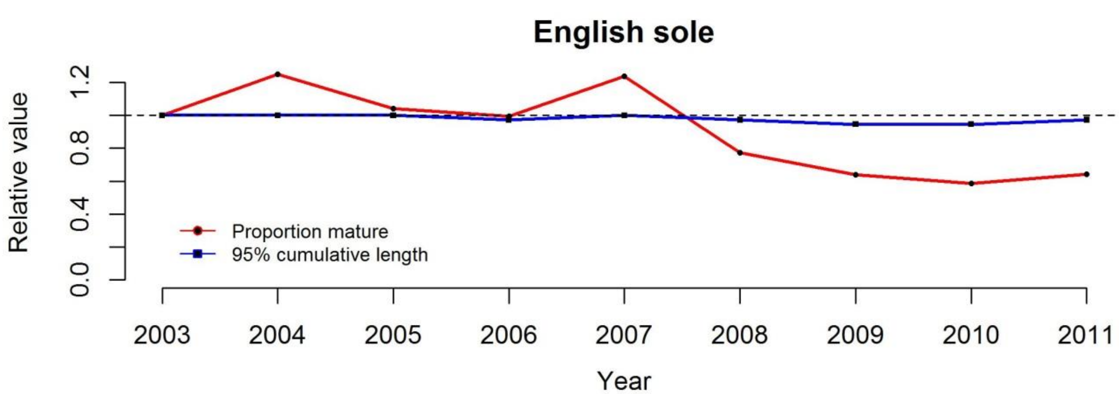

Figure GF46. Proportion of the English sole population mature (red) and at the 95% cumulative length (blue) relative to the first year (2003) of the trawl survey time series.

Summary: English sole show a slight decline in proportion of the oldest ages, but not in proportion mature, over the length of the time series. Recent survey trends in proportion mature are downward.

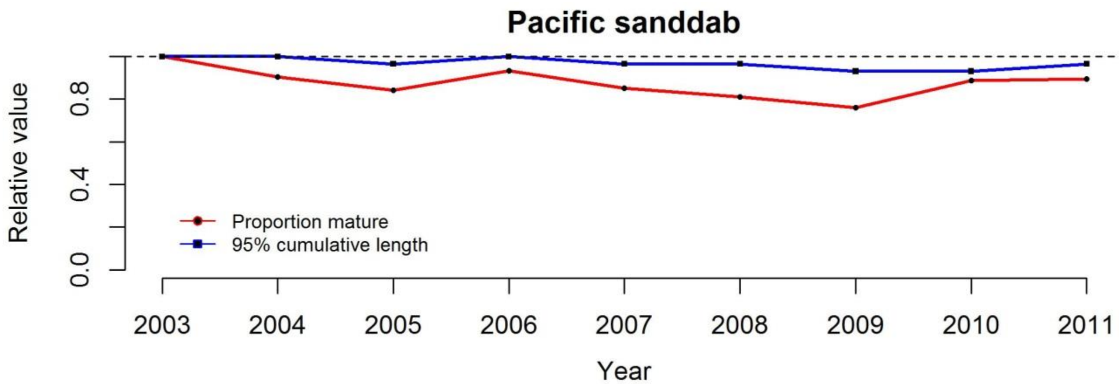

Figure GF47. Proportion of the Pacific sanddab population mature (red) and at the 95% cumulative length (blue) relative to the first year (2003) of the trawl survey time series.

Summary: No stock assessment is available for Pacific sanddab so no baseline information on deomgraphic structure is available. No declines in either maturity or proportion of the largest lengths are apparent from the trawl survey data.

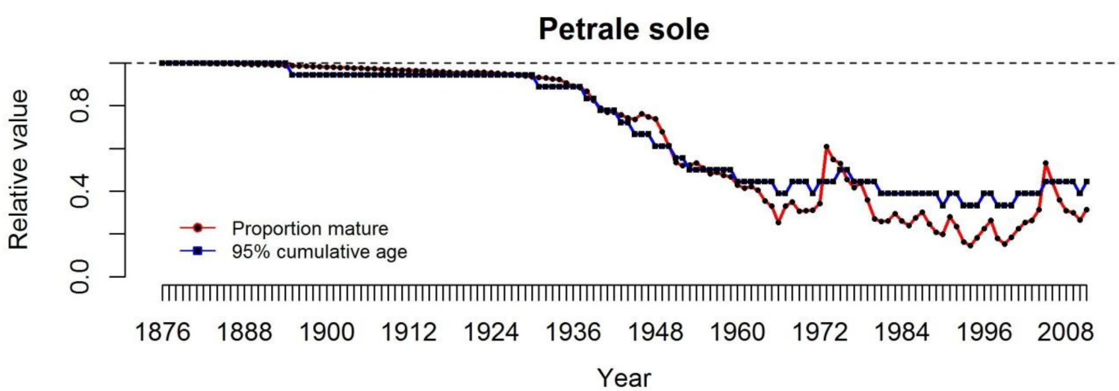

Figure GF48. Proportion of the Petrale sole population mature (red) and at the 95% cumulative age (blue) relative to the first year (1876) of the time series.

Summary: Petrale sole shows notable declines in proportion mature and proportion of the oldest ages over the length of the time series.

Slope

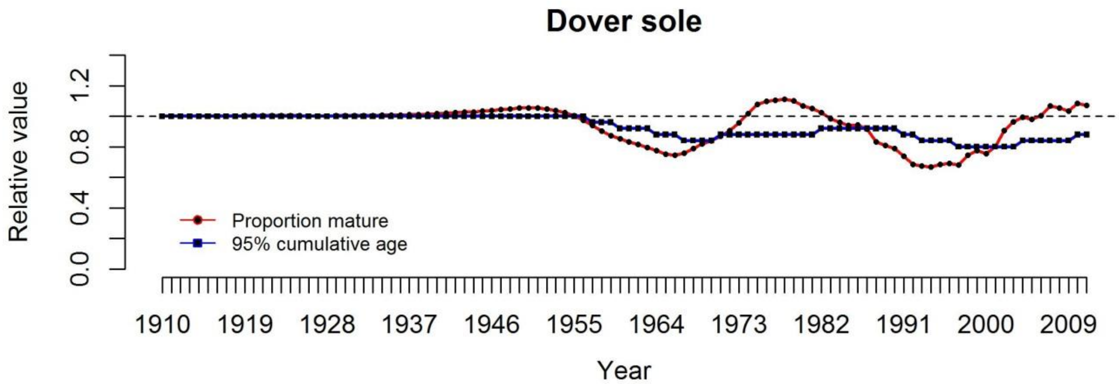

Figure GF49. Proportion of the Dover sole population mature (red) and at the 95% cumulative age (blue) relative to the first year (1910) of the time series.

Summary: Dover sole do not show any notable changes in proportion mature and proportion of the oldest ages and largest lengths over the length of the time series.

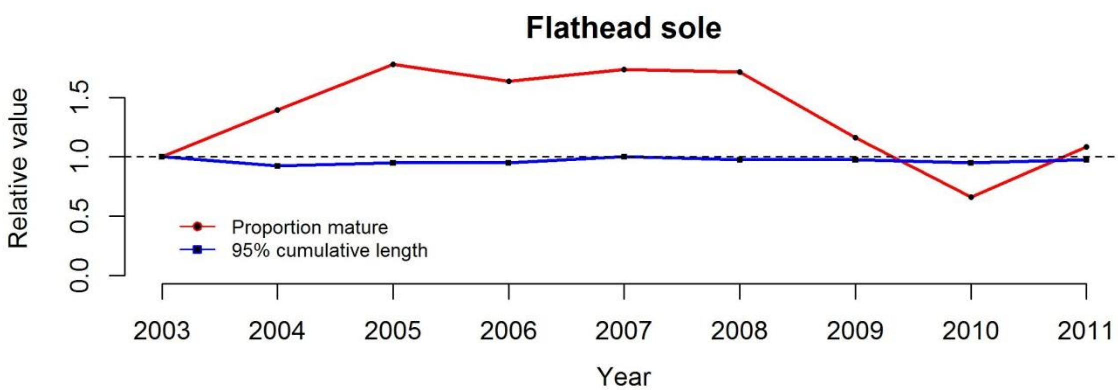

Figure GF50. Proportion of the flathead sole population mature (red) and at the 95% cumulative length (blue) relative to the first year (2003) of the trawl survey time series.

Summary: No stock assessment is available for flathead sole so no baseline information on demographic structure is available. No declines in either maturity or proportion of the largest lengths are apparent from the trawl survey data.

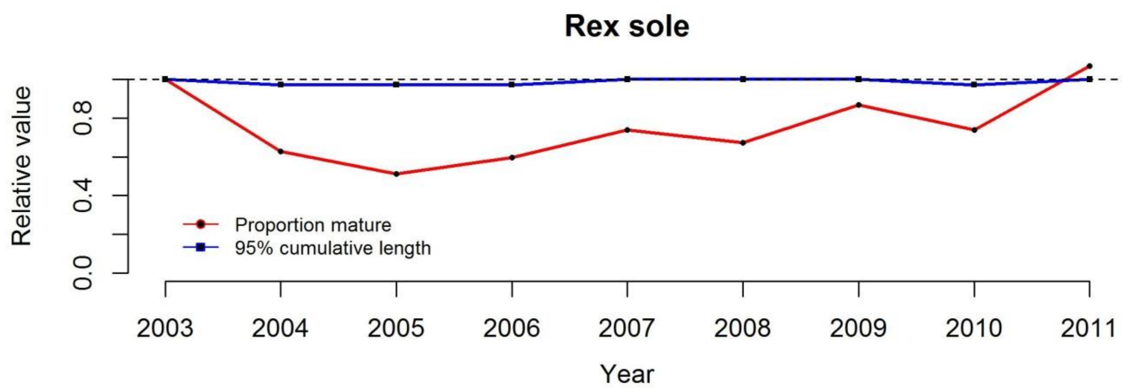

Figure GF51. Proportion of the rex sole population mature (red) and at the 95% cumulative length (blue) relative to the first year (2003) of the trawl survey time series.

Summary: No stock assessment is available for rex sole so no baseline information on demographic structure is available. No declines in either maturity or proportion of the largest lengths are apparent from the trawl survey data.

Rockfishes (N=18)

Nearshore

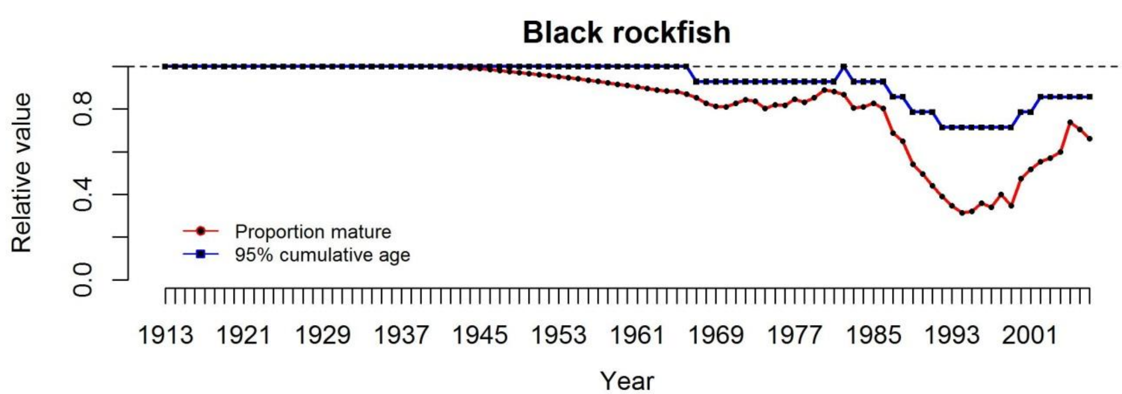

Figure GF52. Proportion of the black rockfish population mature (red) and at the 95% cumulative age (blue) relative to the first year (1916) of the time series.

Summary: Black rockfish show notable declines in proportion mature and slight declines in proportion of the oldest ages over the length of the time series.

Shelf

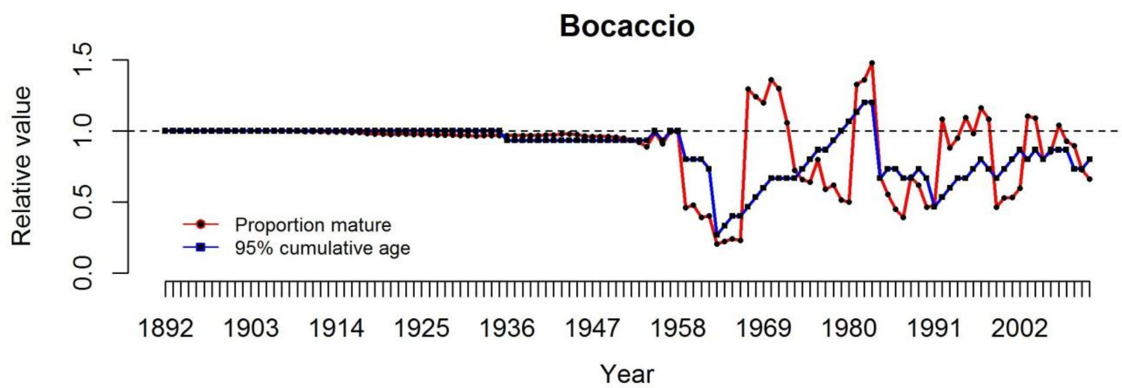

Figure GF53. Proportion of the bocaccio population mature (red) and at the 95% cumulative age (blue) relative to the first year (1895) of the time series.

Summary: Bocaccio show high variation in the proportion mature and proportion of the oldest ages over the length of the time series. The most recent measure are below historical reference levels. Fluctuations may be due to high but sporadic

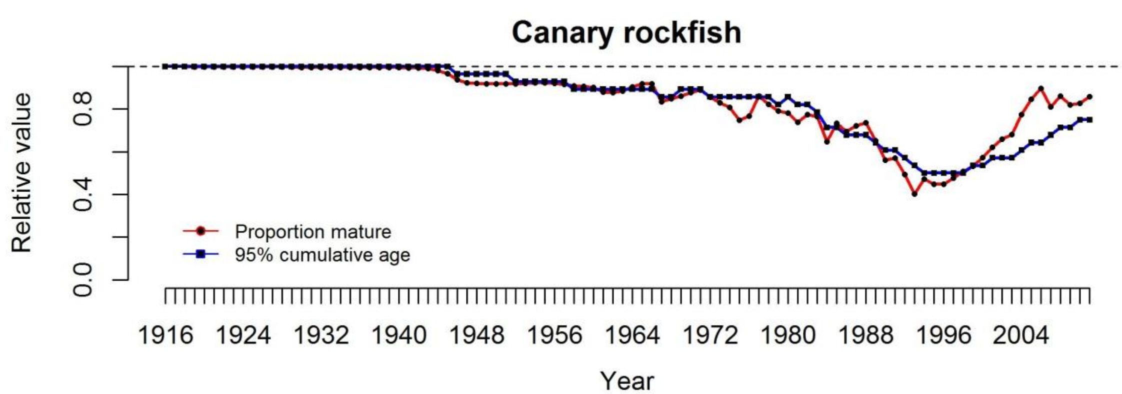

Figure GF54. Proportion of the canary rockfish population mature (red) and at the 95% cumulative age (blue) relative to the first year (1916) of the time series.

Summary: Canary rockfish show declines in proportion mature and proportion of the oldest ages over the length of the time series, but current years demonstrate a building up of both metrics.

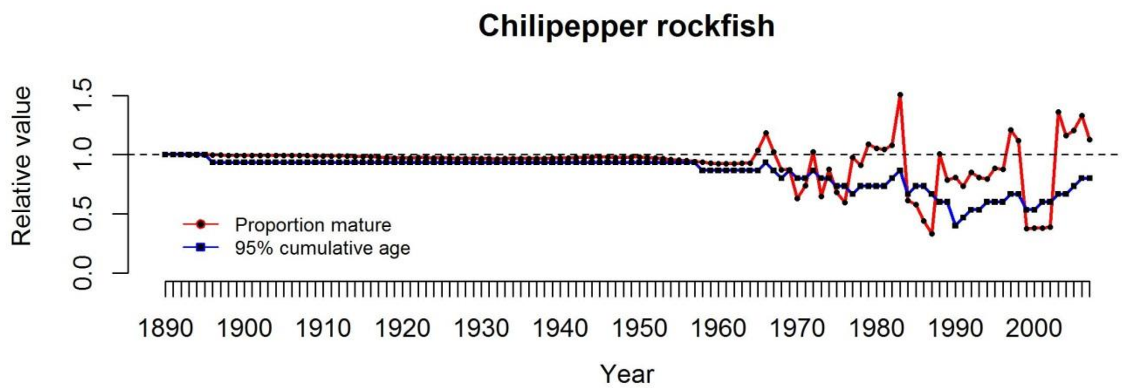

Figure GF55. Proportion of the chilipepper rockfish population mature (red) and at the 95% cumulative age (blue) relative to the first year (1892) of the time series (1892-2007).

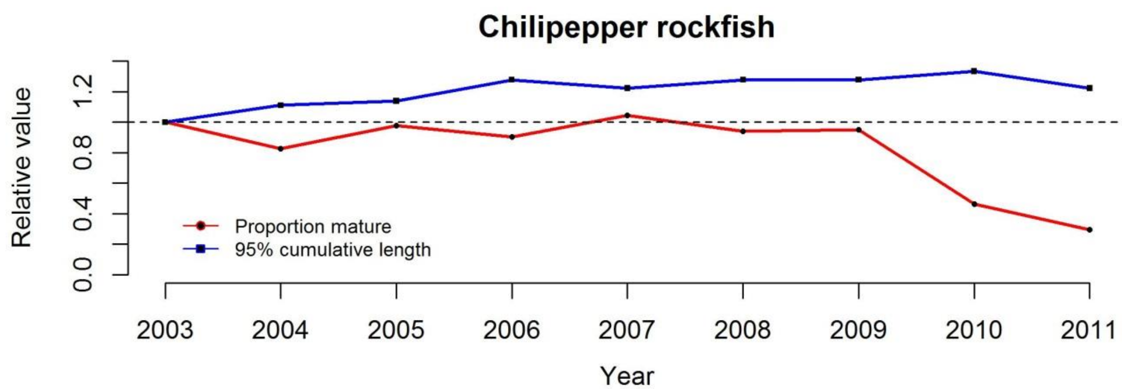

Figure GF56. Proportion of the chilipepper rockfish population mature (red) and at the 95% cumulative length (blue) relative to the first year (2003) of the trawl survey time series (2003-2007).

Summary: Chilipepper rockfish show decreases in proportion mature and proportion of the oldest ages and largest lengths over the length of the time series. The short-term series shows a relative changes consistent with the long-time series when the same relative time frame in considered.

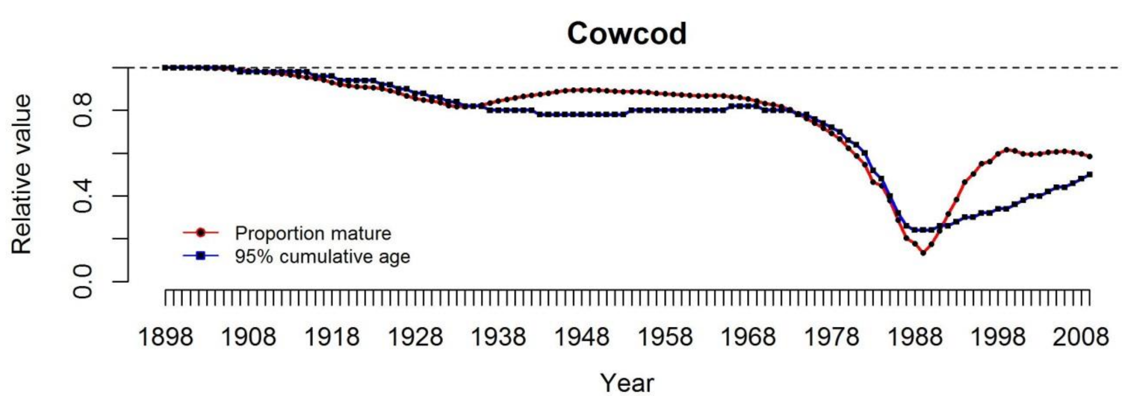

Figure GF57. Proportion of the cowcod population mature (red) and at the 95% cumulative age (blue) relative to the first year (1900) of the time series.

Summary: Cowcod show declines in proportion mature and proportion of the oldest ages over the length of the time series.

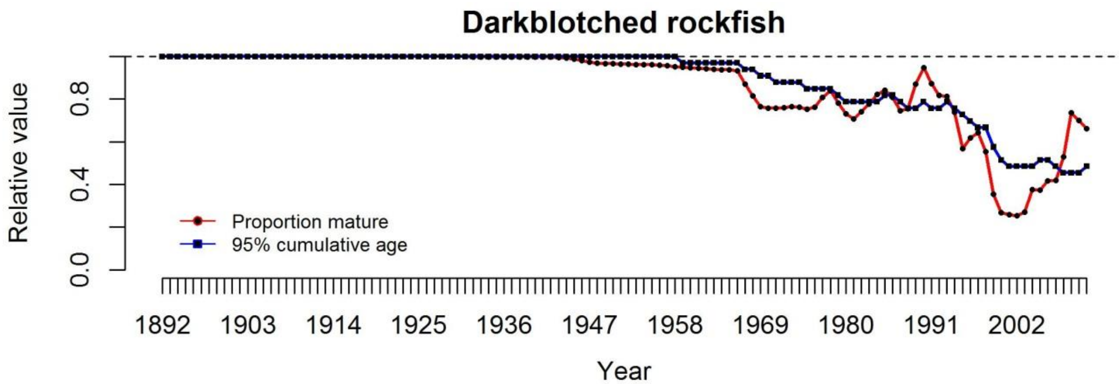

Figure GF58. Proportion of the darkblotched rockfish population mature (red) and at the 95% cumulative age (blue) relative to the first year (1895) of the time series.

Summary: Darkblotched rockfish show declines in proportion mature and proportion of the oldest ages over the length of the time series.

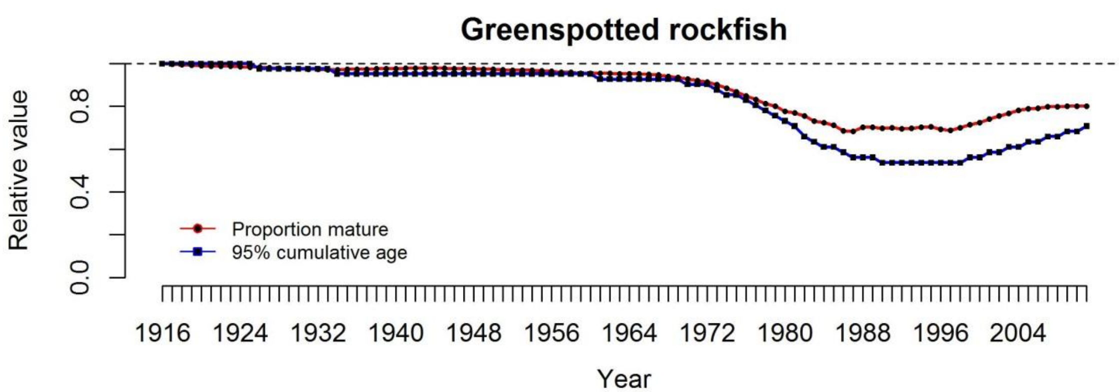

Figure GF59. Proportion of the greenspotted rockfish population mature (red) and at the 95% cumulative age (blue) relative to the first year (1916) of the time series.

Summary: Greenspotted rockfish show declines in proportion mature and proportion of the oldest ages over the length of the time series.

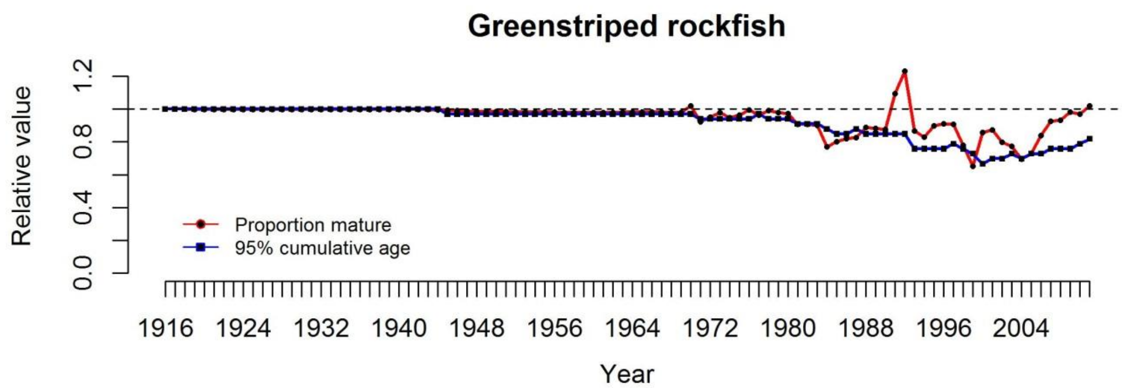

Figure GF60. Proportion of the greenstriped rockfish population mature (red) and at the 95% cumulative age (blue) relative to the first year (1916) of the time series.

Summary: Greenstriped rockfish show little change in proportion mature and proportion of the oldest ages over the length of the time series, with only a small decrease in population structure.

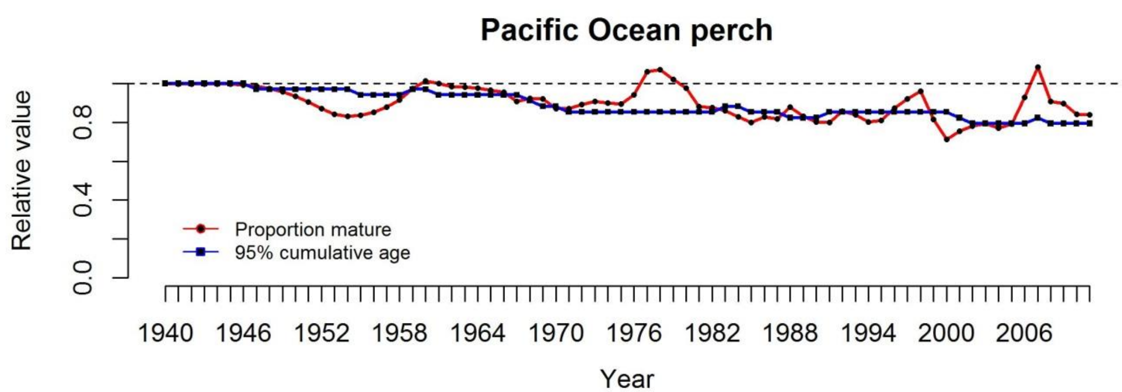

Figure GF61. Proportion of the Pacific Ocean perch population mature (red) and at the 95% cumulative age (blue) relative to the first year (1940) of the time series.

Summary: Pacific Ocean perch show low levels of decline in proportion mature and proportion of the oldest ages over the length of the time series.

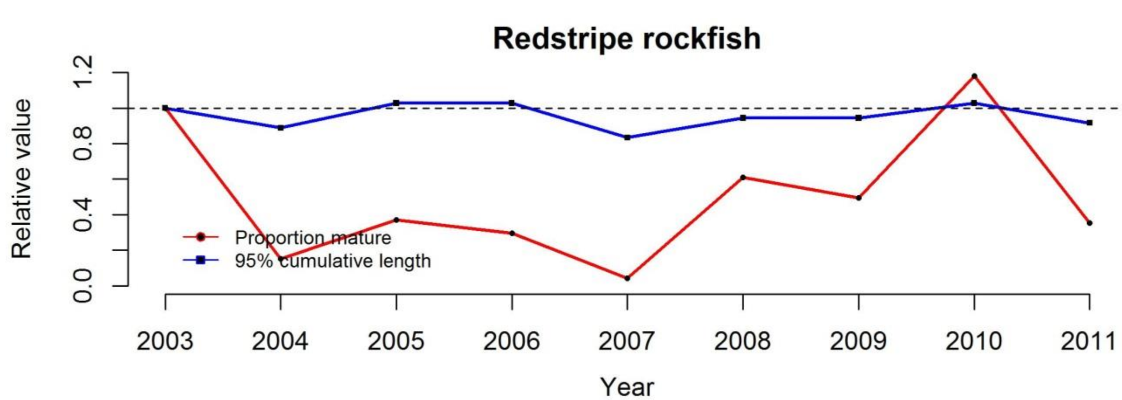

Figure GF62. Proportion of the redstripe rockfish population mature (red) and at the 95% cumulative length (blue) relative to the first year (2003) of the trawl survey time series.

Summary: No stock assessment is available for redstripe rockfish so no baseline information on demographic structure is available. No declines in maturity are apparent from the trawl survey data, though proportion of the largest lengths is variable across years with a notable decline.

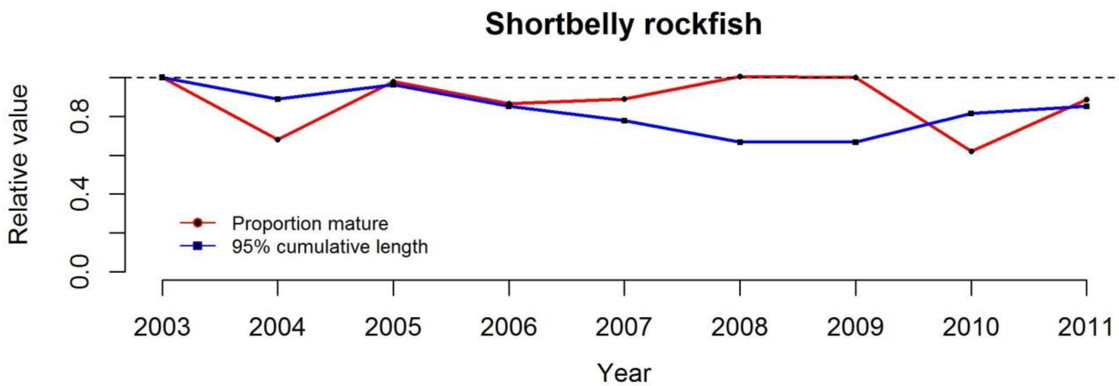

Figure GF63. Proportion of the shortbelly rockfish population mature (red) and at the 95% cumulative length (blue) relative to the first year (2003) of the trawl survey time series.

Summary: Only modest declines in either maturity or proportion of the largest lengths are apparent from the trawl survey data for shortbelly rockfish.

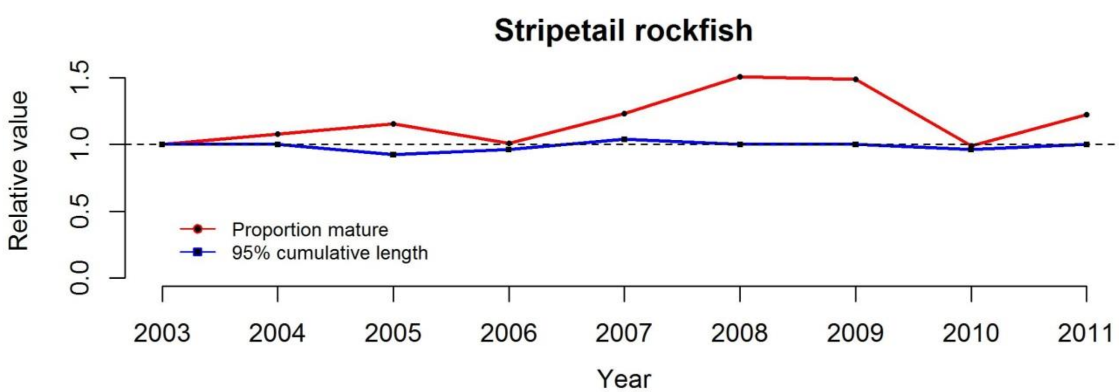

Figure GF64. Proportion of the stripetail rockfish population mature (red) and at the 95% cumulative length (blue) relative to the first year (2003) of the trawl survey time series.

Summary: No stock assessment is available for stripetail rockfish so no baseline information on demographic structure is available. No declines in either maturity or proportion of the largest lengths are apparent from the trawl survey data.

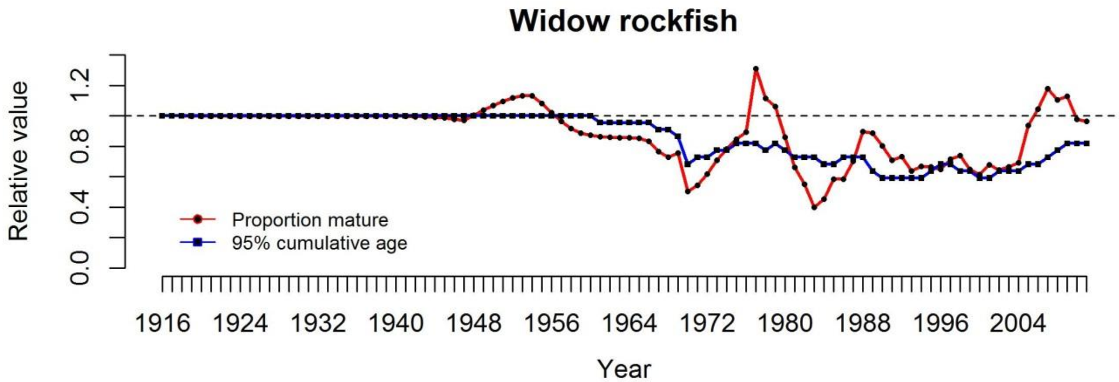

Figure GF65. Proportion of the widow rockfish population mature (red) and at the 95% cumulative age (blue) relative to the first year (1916) of the time series.

Summary: Widow rockfish show no declines in proportion mature and population structure over the length of the time series that have returned or are building back towards historical levels.

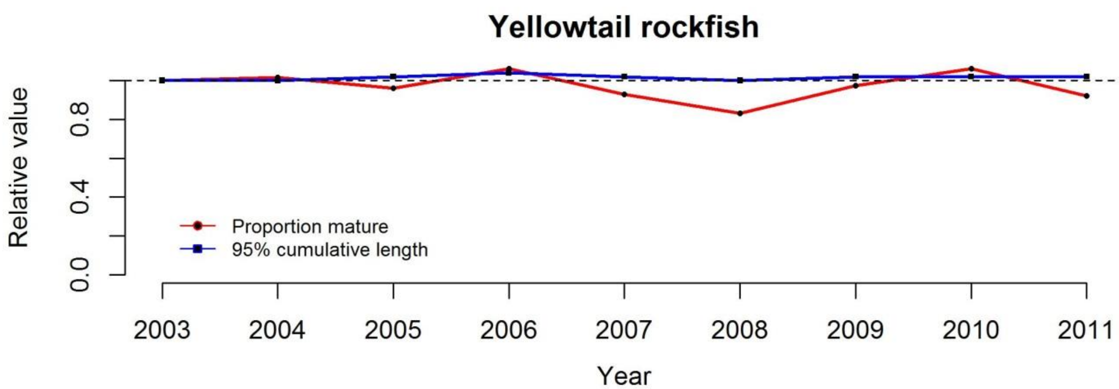

Figure GF66. Proportion of the yellowtail rockfish population mature (red) and at the 95% cumulative length (blue) relative to the first year (2003) of the trawl survey time series.

Summary: No declines in either maturity or proportion of the largest lengths are apparent from the trawl survey data for yellowtail rockfish.

Slope

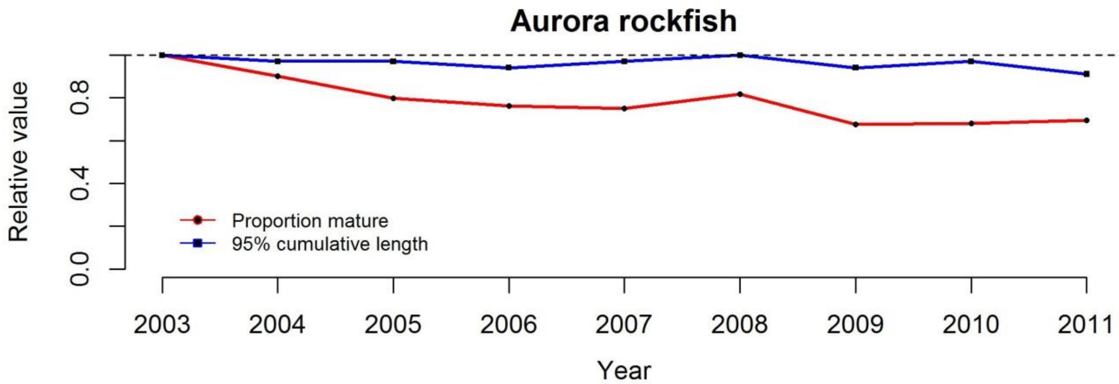

Figure GF67. Proportion of the aurora rockfish population mature (red) and at the 95% cumulative length (blue) relative to the first year (2003) of the trawl survey time series.

Summary: No stock assessment is available for aurora rockfish so no baseline information on demographic structure is available. Modest declines proportion of the largest lengths, but stronger declines in proportion mature are apparent from the trawl survey data.

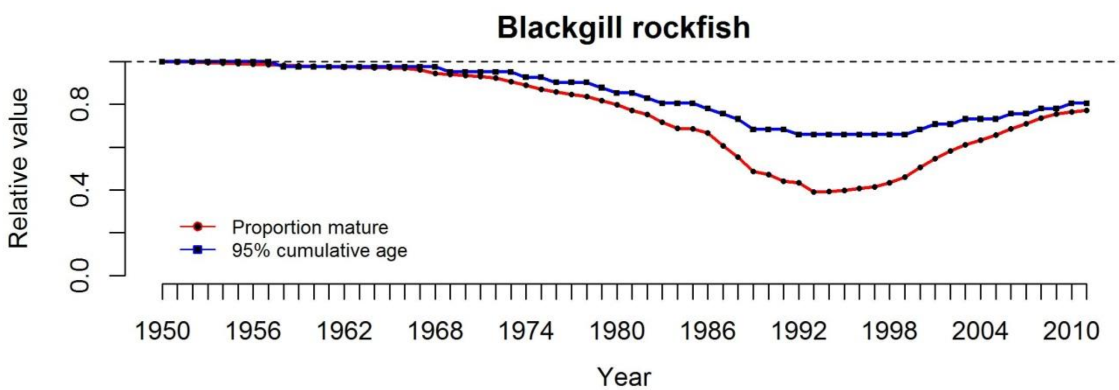

Figure GF68. Proportion of the blackgill rockfish population mature (red) and at the 95% cumulative age (blue) relative to the first year (1950) of the time series.

Summary: Blackgill rockfish show declines in proportion mature and proportion of the oldest ages over the length of the time series.

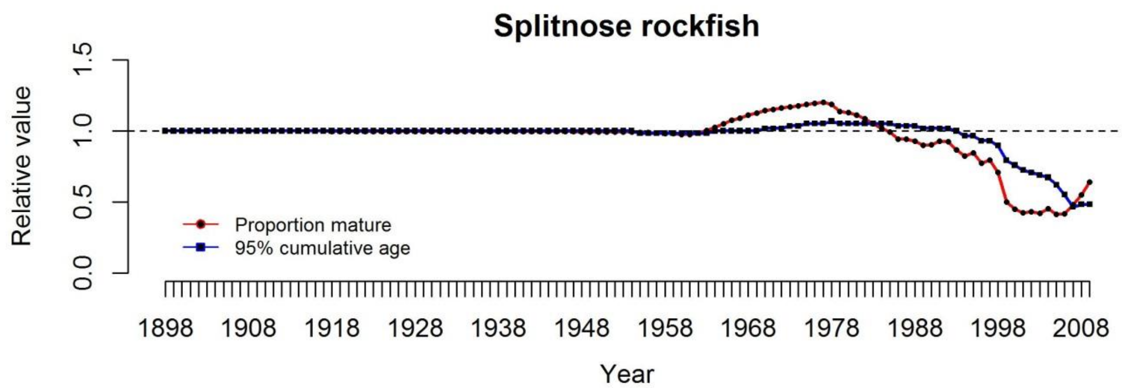

Figure GF69. Proportion of the splitnose rockfish population mature (red) and at the 95% cumulative age (blue) relative to the first year (1900) of the time series.

Summary: Splitnose rockfish show declines in proportion mature and proportion of the oldest ages over the length of the time series.

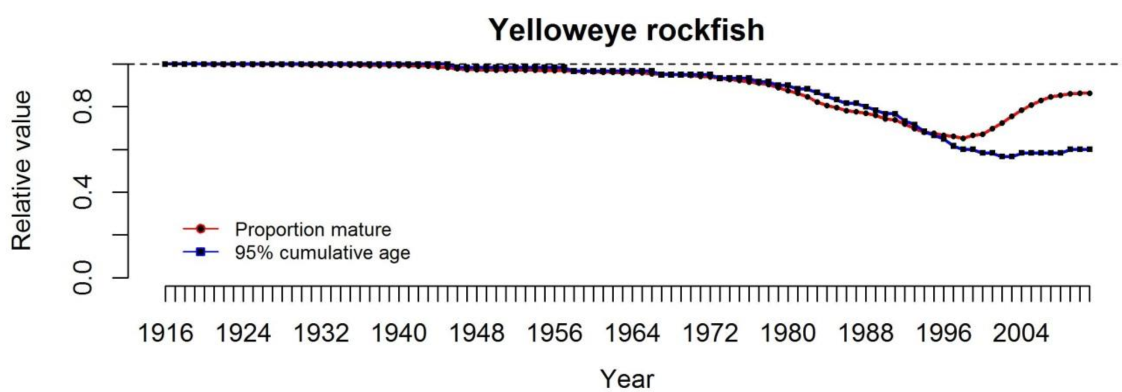

Figure GF70. Proportion of the yelloweye rockfish population mature (red) and at the 95% cumulative age (blue) relative to the first year (1916) of the time series.

Summary: Yelloweye rockfish show have declines in proportion mature and proportion of the oldest ages over the length of the time series.

Other fishes (n=3)

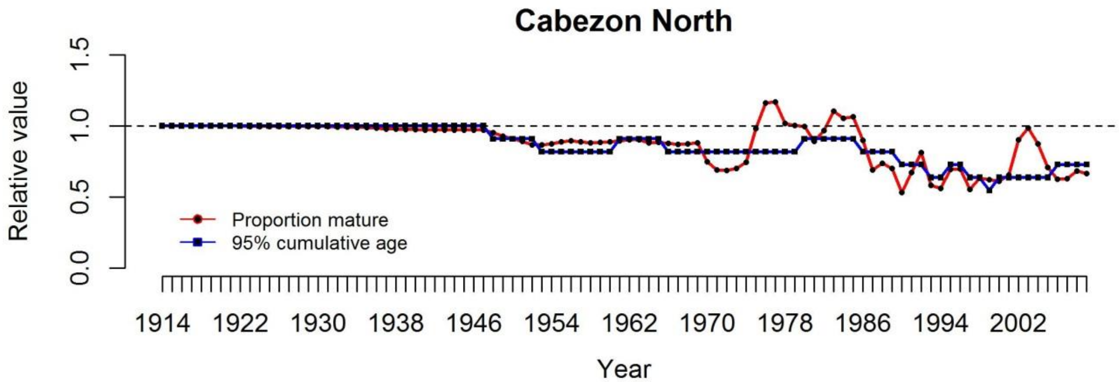

Figure GF71. Proportion of the cabezon population mature (red) and at the 95% cumulative age (blue) relative to the first year (1916) of the time series.

Summary: Cabezon show declines in proportion mature and proportion of the oldest ages over the length of the time series.

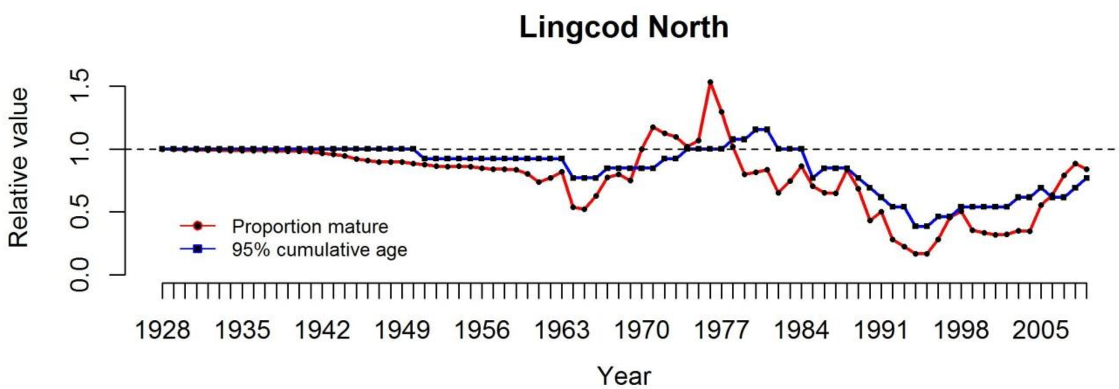

Figure GF72. Proportion of the lingcod population mature (red) and at the 95% cumulative age (blue) relative to the first year (1930) of the time series.

Summary: Lingcod show declines in proportion mature and proportion of the oldest ages that have recently shown increases towards historical levels.

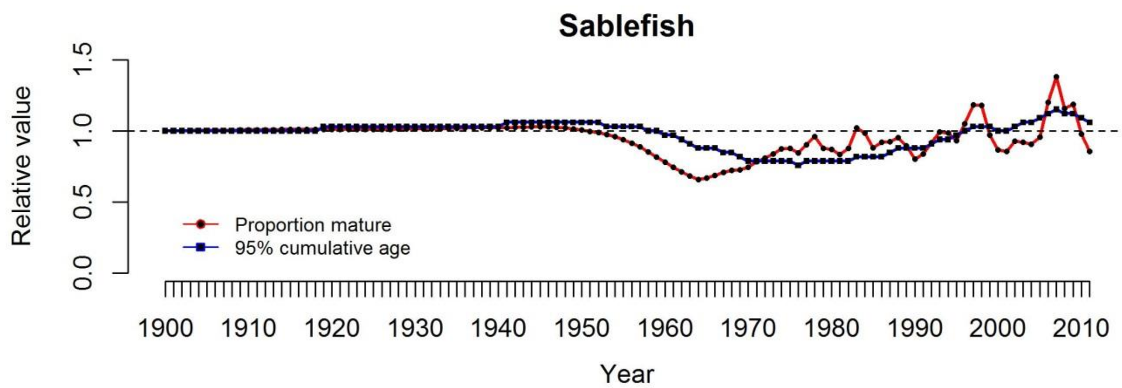

Figure GF73. Proportion of the sablefish population mature (red) and at the 95% cumulative age (blue) relative to the first year (1900) of the time series.

Summary: Sablefish show little change in proportion mature and proportion of the oldest ages over the length of the time series.

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